POWER

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The Thoughts of It O'Nights

I SUPPOSE we all have those spells of wakefulness when the "Sleep that knits up the ravell'd sleave of care" will not come and we toss and turn and think of all the fool things that we have done and of all the wise things that we ought to have done and vex our souls with vain regrets.

These things lose much of their hideous import with the coming of the day, but they are blots and blemishes, and many of them could have been so easily avoided.

The errors of commission are often due to impulsiveness, to lack of deliberation, to the thoughtless taking of a chance, to the heating up of more irons than one can handle.

In things mechanical they come from a too eager striving for achievement, from an ill-considered reaching out beyond demonstrably sound practice.

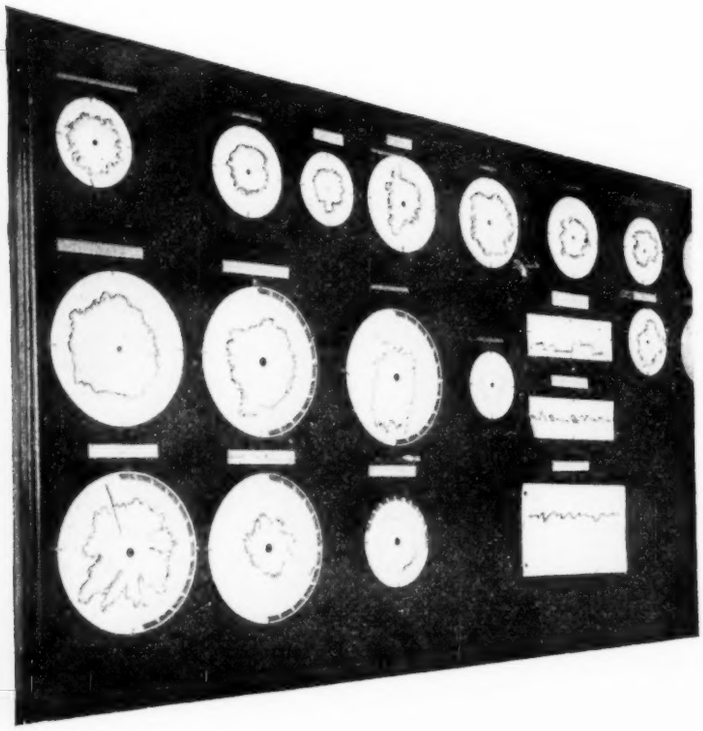
It was a favorite remark of John Sweet, with regard to good design and the avoidance of engineering excesses, that "It lets one sleep well o'nights."

This does not mean a timid adherence to present practice—a cowardly conservatism that brakes the wheels of progress—but a careful study of the lay of the land toward the region into which one is venturing and a weighing of the possible difficulties and danger against the promised advantages to see if the game is worth the candle.

The best anchor to which to hitch a mind in this fluttering condition is something that one has done well and creditably. Even a small thing of this kind will often neutralize the poignancy of regret and still both mind and body so that sleep may settle down upon them.

A wise consideration in determining whether one shall or shall not do a thing is whether in the time to come the thoughts of it will be a comfort or a torture when they come to one o'nights

F. R. Low



WHEN a member of the *Power* staff visited the Union Power Plant of the Hercules Powder Company at Parlin, N. J., he found plenty of records. The charts from the recording instruments are posted on a board daily, so that they are visible for ready inspection. Previous records are filed systematically near-by

Sixty-four per Cent Less Coal per Pound of Product

IMPROVED combustion, utilization of exhaust steam, installation of recording instruments and machines of proper capacity, together with simplified methods of production, effect an

Annual Saving of $175,000

in the Union Plant of the Hercules Powder Company

INCREASING the average over-all boiler efficiency from 54.8 to 77 per cent and decreasing the pounds of coal per pound of product 64 per cent has been accomplished by the Hercules Powder Company at its Union Plant, Parlin, N. J.

The plant was erected by the T. A. Gillespie Company of New York, in 1915, for the manufacture of smokeless powder. Shortly after its completion it was purchased by the Hercules Powder Company, which continued the production of smokeless powder until the close of the War in 1918. The manufacture of soluble nitro-cellulose was started at this time. This product is used in the manufacture of artificial leather, lacquers and celluloid. A careful study of the power requirements for the manufacture of the new product showed that the capacity of some of the power-plant machinery and other power apparatus as installed for munitions manufacture was entirely too large for efficient production. In spite of this knowledge it was decided to continue operation until the sale of the new product became more promising. The future of the business was assured early in 1923, when a practical process was developed for the production of low-viscosity nitro-cellulose. This ushered in a phenomenal lacquer business and resulted in the immediate formulation of definite plans for the more efficient operation of the plant.

Prior to the starting of the revamping program, recording instruments were absent entirely and the major part of the steam from the non-condensing turbines was being exhausted to the atmosphere. Oversize feed pumps, exciters, compressors, motors, etc., were operating at fractional loads and therefore inefficiently. These conditions caused a tremendous waste of steam and electricity. A still further waste was occurring in the combustion of the boiler fuel, since the boiler efficiency was only 54.8 per cent. The operating figures for 1926 showed conclusively that the various changes had produced the results desired.

The average coal consumption amounted to 2,256,000 lb. during 1926, and 22,976,000 lb. of water was evaporated from feed water at 200.5 deg. F. to saturated steam at 155 lb. gage pressure. This corresponds to an actual evaporation of 10.18 lb. of water per pound of coal burned. The average heat value of the Norton

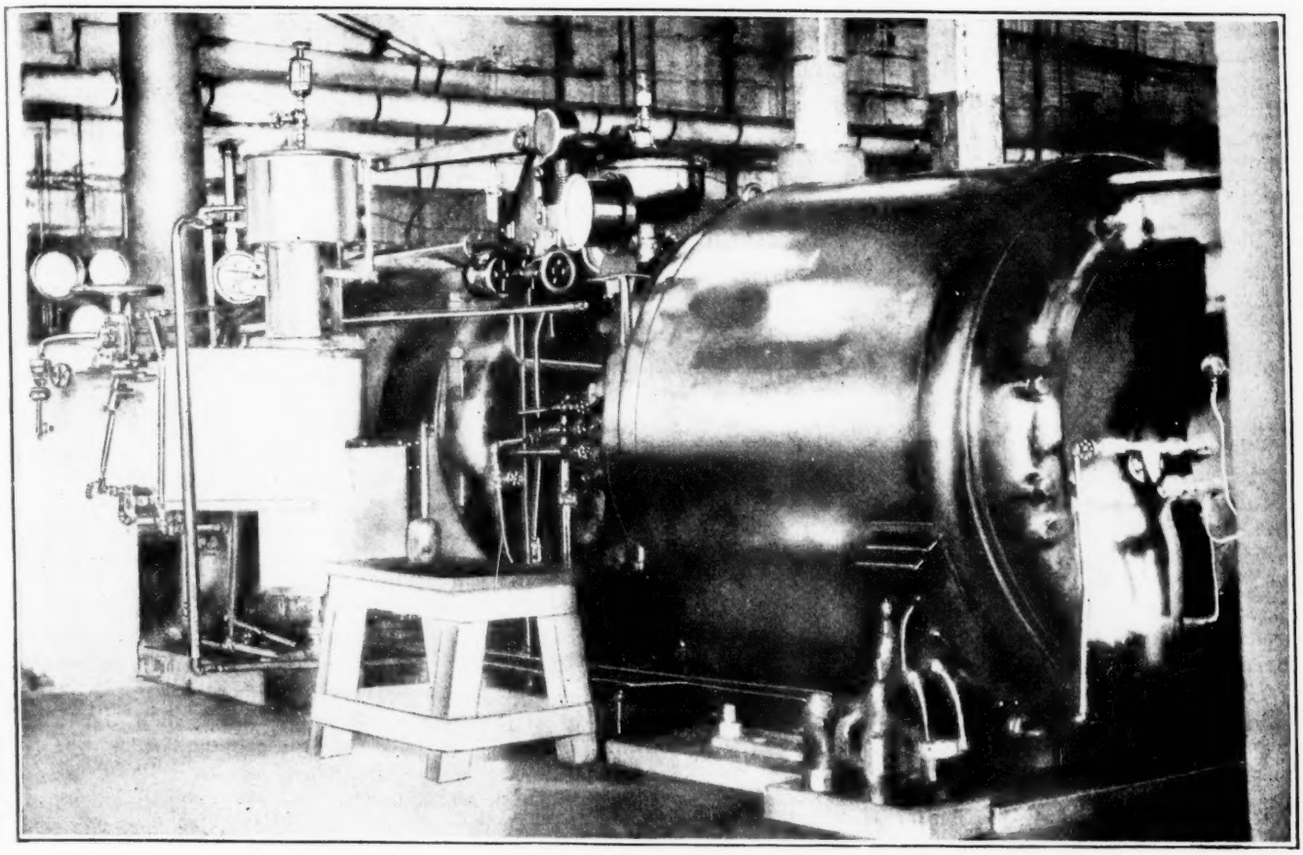


Fig. 1—New 600-kw. condensing turbine-generator unit is in service seven days per week and operates at its most efficient point

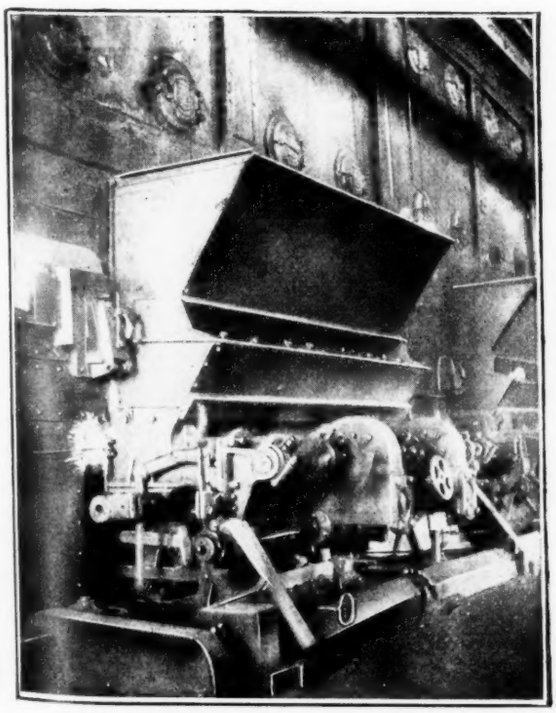


Fig. 2—Underfeed stoker-fired boilers

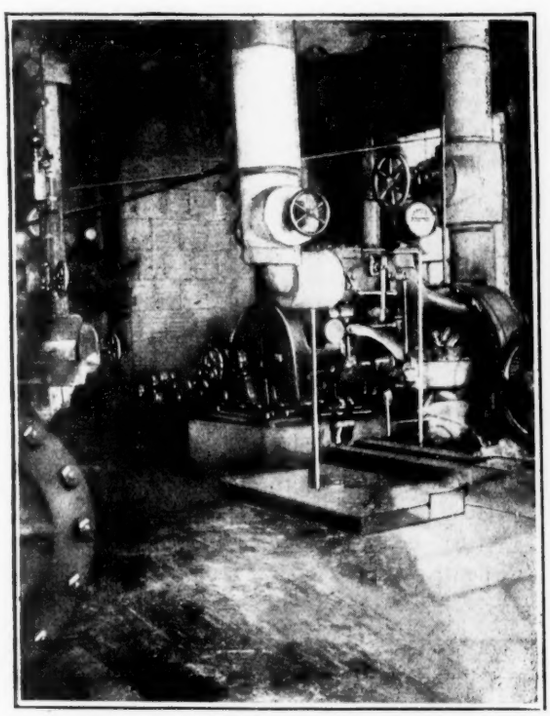


Fig. 3—Section of new pumproom

Mine bituminous coal, as determined by the company's chemist from coal-pile samples, showed 13,470 B.t.u. per lb. From the foregoing data the over-all boiler efficiency is 77 per cent. This corresponds to an increase of 22.2 points over the boiler efficiency for 1923. The flue temperature records showed an average of 450 deg. F., and the CO_2 records indicated an average of 14 per cent. A laboratory analysis of the coal fired determined an ash content of 12 per cent. The high boiler efficiency has been attained even though economizers or air heaters are not installed.

Careful Thought Given to All Factors

All feed water is heated by an open-type regulated heater and measured by a recording meter. Coal is weighed on a larry, and all instruments are checked regularly for accuracy. The flue temperature is recorded by a recording thermometer, and the hand-regulated drafts above and below the fire are determined by a draft gage.

These results were not accomplished by any hit-or-miss methods. Careful engineering and practical consideration were given to every factor entering into the production and distribution of steam and electricity together with the efficient operation of all auxiliary apparatus and simplified manufacturing processes.

A complete power test costing $5,000 was made before any improvements were undertaken. Many of the instruments used on this test were purchased by the company, together with others totaling a cost of $2,600. This provided a means for operating the plant on a scientific engineering basis.

Bituminous coal, delivered to the plant by the steam railroad, is unloaded from the cars by a locomotive-type bucket crane and deposited on a dump in close proximity to a crusher. About 450 tons is stored at this point. This crane also transfers the coal from the dump to the crusher, whence it is carried to a 200-ton capacity coal bunker by a bucket conveyor. It is transferred from the bunker to the larry by gravity feed.

Proper Capacity Apparatus Contributes to Increase of Efficiency

In the boiler room four 5,000-sq.ft. boilers are installed. Two of these are required for service daily and the other two are held in reserve. These boilers are fired by underfeed stokers and the feed is regulated by a variable speed transmission. Forced draft is supplied by an engine-driven blower, the exhaust steam of which is utilized for feed-water heating. Ashes discharged to a hand truck in the basement are lifted to the boiler-room floor by a hoist and dumped into a pit. The locomotive crane digs the ashes from this pit and they are used for road building or filling purposes. All the boiler-room and coal-handling apparatus was inspected thoroughly and tuned up for first-class operation. Draft and CO_2 recorders were installed. The soot is blown out periodically and unnecessary variations in draft and CO_2 are carefully guarded against.

In 1922, when only 10,239,000 lb. of steam was used per month for the operation of the entire plant, the engine room was equipped with non-condensing turbines of 500 kw. and 1,000 kw. capacity and two 2,500-cu.ft. engine-driven air compressors. The total electrical load at this time was 87,390 kw.-hr. per month. Besides the waste caused by operating these machines at light loads, a still further waste was incurred by non-condensing operation and exhausting the steam to the atmosphere. The 1,000-kw. non-condensing turbine was replaced by a 600-kw. 80 per cent P.F. 480-volt three-phase 60-cycle 3,600-r.p.m. condensing turbine-generator with a barometric condenser. The 500-kw. non-condensing unit was retained as a spare. The two 2,500-cu.ft. engine-driven air compressors were replaced by two 800-cu.ft. engine-driven air compressors. Only one of these compressors is required for daily use and it operates near its most efficient point. All exhaust steam from the engine-room auxiliary apparatus is utilized for process work. These changes, together with the installation of numerous steam and electrical recording meters and careful inspection, repair and adjustment of all engine-room apparatus, have contributed to the increase of efficiency obtained. In addition to the apparatus mentioned, the engine room contains the switching apparatus for the control of the electric current, one 150-kw. 125-volt marine-engine-driven exciter, one 122.5-kw. 125-volt induction motor-generator set, one 5½-kw. induction motor-generator battery charging set and an engine-driven vacuum pump.

Relocating Pumproom Proves Economical

The greater portion of the power plant was constructed of corrugated iron originally, and the pump-room was about 100 ft. from the engine room. A major portion of the building has been remodeled with brick and fire brick. Some of the pumping equipment was entirely too large for the work it was called upon to perform and, as a result, was operating inefficiently. Steam was exhausted to the atmosphere, and the location of the apparatus required an additional force to take care of its operation. A brick building was erected adjacent to the engine room and the pumping apparatus reinstalled in this new location. One of the two 3,500-g.p.m. feed-water pumps was replaced by a new 70-g.p.m. feed-water pump. The second 350-g.p.m. pump is held as a reserve unit. The pumproom contains also one 1,200-g.p.m. turbine-driven pump and one motor-driven pump of 300 g.p.m. capacity. These pumps are used for fire service only. In addition, there are a 1,400-g.p.m. turbine-driven service water pump, a 1,400-g.p.m. motor-driven pump and one 800-gal. motor-driven condenser pump. Exhaust steam from the turbine-driven service pump is utilized for process work. This arrangement has effected a saving in steam, labor costs have been decreased by placing the apparatus within observation of the engine-room attendant, and the operating efficiency has been increased by the selection of machines to operate at or near their most efficient point.

Water Aeration Decreases Boiler Maintenance

The circulating water was being pumped by inefficient apparatus in 1923 and was costing approximately 0.0788c. per gal. This apparatus was discarded and a modern vertical pump, driven by a 40-hp. induction motor was installed, with the result that in 1926 the cost of production per gallon decreased to 0.0349c. It was installed in a separate building and supplied with modern automatic starting apparatus and a recording water meter.

The water in this locality contains considerable iron and sulphur. It was treated unsatisfactorily with lime prior to 1923, which resulted in boiler deterioration with resultant higher maintenance costs. An aëration plant was installed to overcome this objectionable feature. This plant consists of a 50,000-gal. concrete reservoir totally inclosed and a 3.33-cu.ft. displacement per

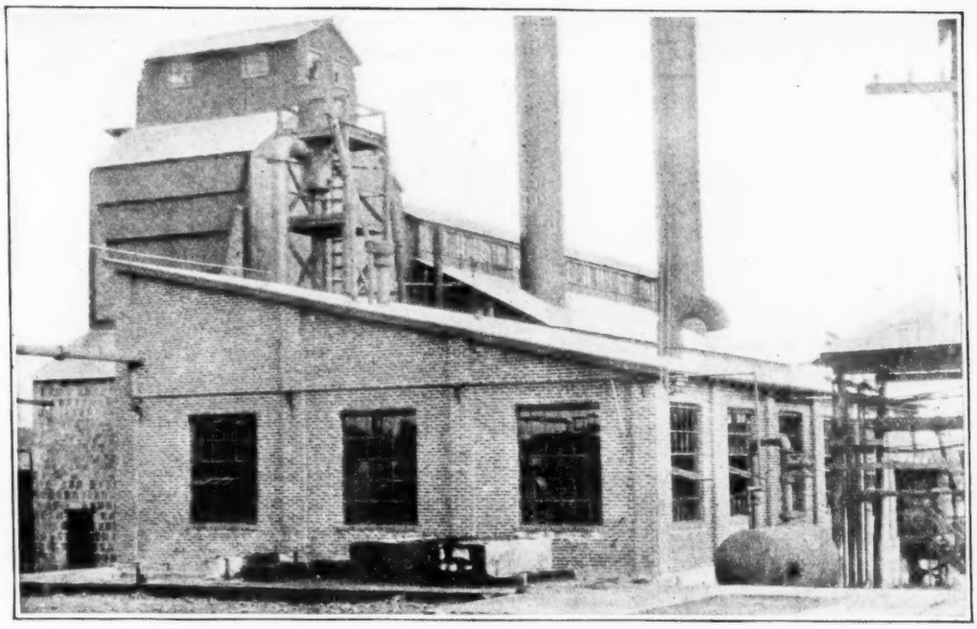


Fig. 4—View of remodeled power plant

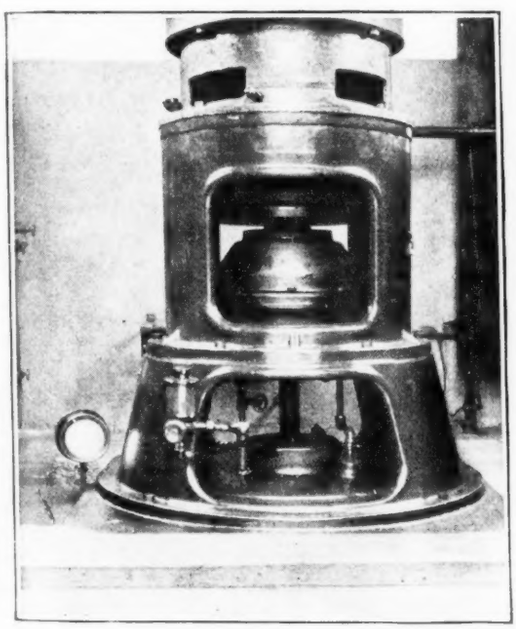


Fig. 5 (Above)—Vertical motor-driven deep-well pump

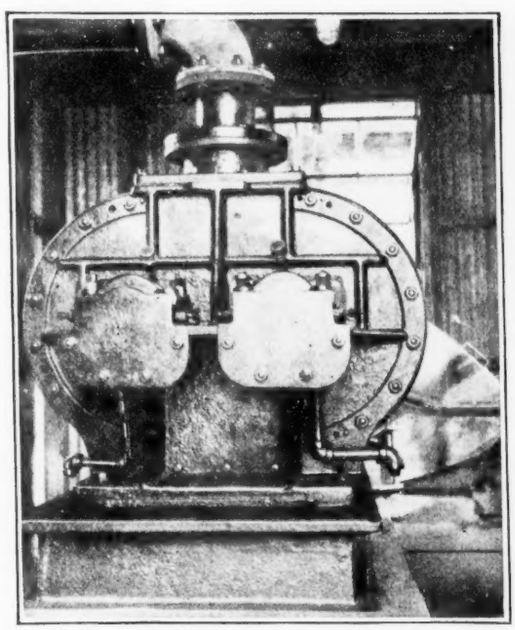


Fig. 6 (Above)—Motor-driven air pump for aëration reservoir

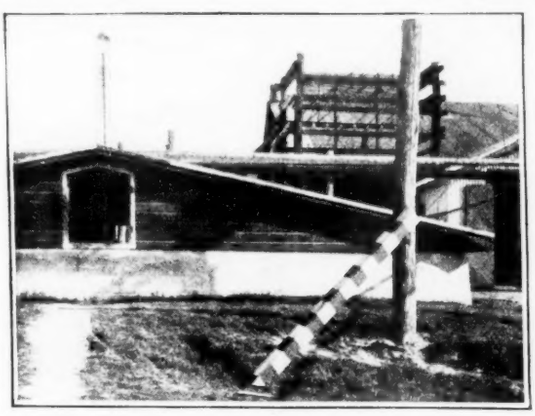


Fig. 7 (Left)—Aëration reservoir and air-pump house

The height of water gage and accident prevention device on guy wire is conspicuous.

revolution blower driven through a silent chain by a 20-hp. induction motor. The blower apparatus is installed in a brick building adjacent to the reservoir. An illuminated scale mounted on top of the reservoir roof indicates the height of the water through the medium of a float. This gage is of such a size and height as to be visible to the station engineer approximately 100 ft. distant. Air is pumped into the bottom of a section of the reservoir formed by a concrete wall extending practically across its width and is equally distributed over the area by an air diffuser. This method of air purification, together with a sand filter located between the reservoir and the feed-water pump, has afforded a means for practically eliminating the objectionable chemical elements which previously caused considerable boiler trouble.

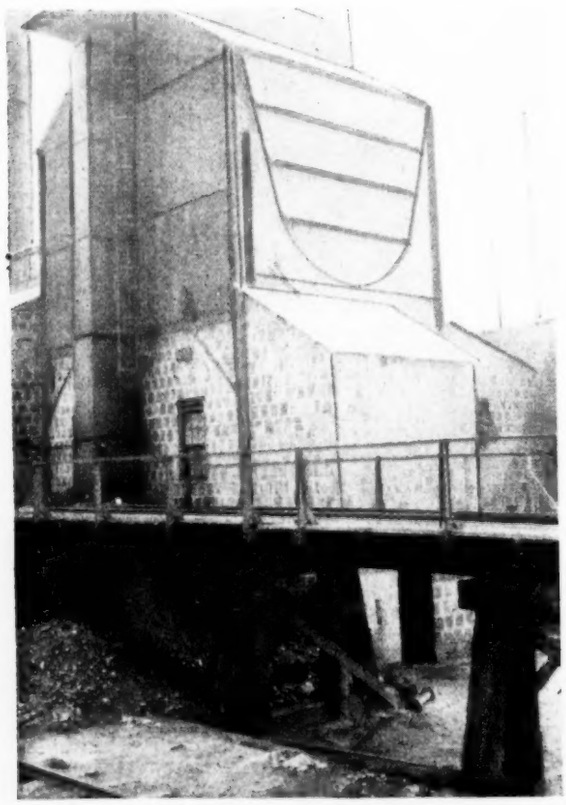


Fig. 8—Coal bunker and conveyor

Extensive use of modern steam traps and their careful maintenance has contributed to the improvement in the operating efficiency. Heat insulation has been given considerable attention. The various motor- and steam-driven units were rearranged throughout the manufacturing plant so that each machine would operate at its most efficient point. The main steam line is bypassed when the exhaust steam is used for boiling purposes, so that, when the liquid reaches the boiling point, only sufficient steam is admitted to keep it boiling. Hot water is transferred from building to building where possible in order that every unit of heat value can be utilized.

COMPARISON OF 1922 AND 1926 COSTS EXCLUSIVE OF FIXED CHARGES

	1,000 Lb. Steam	Kw.-Hr. Generated	Air 1,000 Cu.Ft.	Gal. of Water Pumped
1922	0.673	0.0467	0.0582*	0.0788*
1926	0.318	0.0125	0.0442	0.0457

*According to the old power constants in use in 1922 the actual cost was undoubtedly very much higher.

As a result of the improvements and the careful attention given to the operation and maintenance of the entire equipment it is expected that the 1927 performance will be better than that of 1926.

Power is indebted to A. B. Nixon, superintendent, and M. G. Milliken, assistant superintendent, of the Hercules Powder Co., Parlin, N. J., for the data and information incorporated in this article.

Regulation of Load Between Power Plant Units

On most large systems the regulation or distribution of load between electric units is maintained by switchboard control of the governors, according to a recent report made by the National Electric Light Association's Hydraulic Power Committee. Where two waterwheels are connected to the same units, as is frequently done with impulse turbines, the floor man regulates the two needle valves so that they operate with the same opening, the total load on the unit being regulated from the switchboard by means of the governor control.

The majority of companies depend upon the inherent governing capacity of the governors, with the addition of a stop, as the load limiting device, when desirable. In such cases directions are signalled by hand or otherwise to the floor men. Some of the companies state that the requirements of their systems are becoming such as to make it desirable to install some additional means of direct, positive control from the switchboard. The load distribution among various plants on the system is controlled by the system load dispatcher or operator through instructions sent by telephone or otherwise, to the various generating stations.

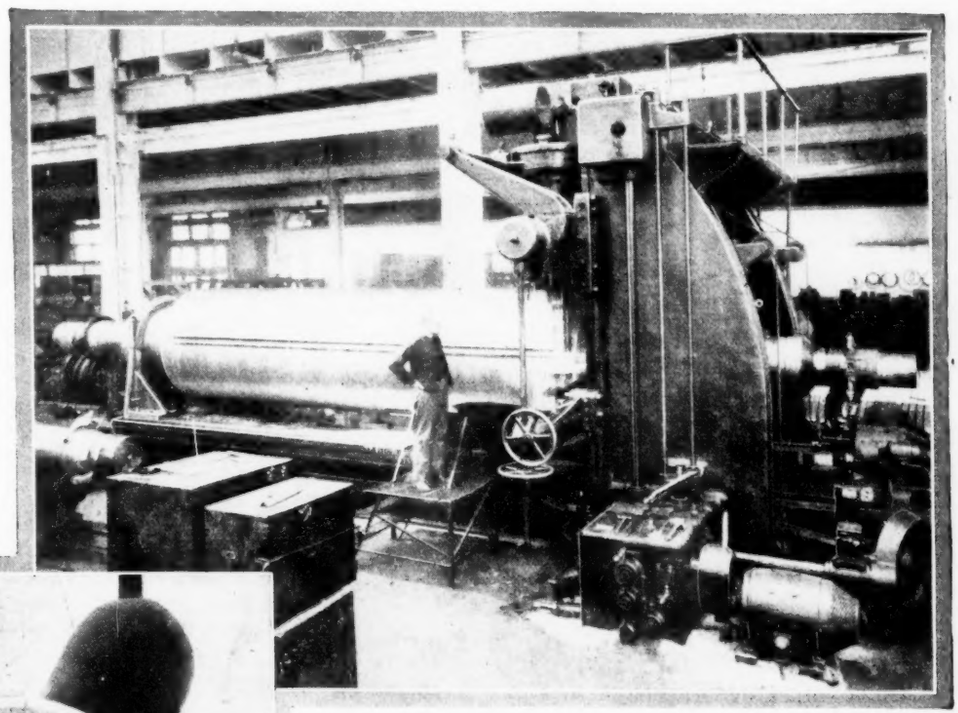
The maximum speed of governor operation that may be safely maintained with a hydro unit is dependent upon the head and length of pipe line or water conduit leading to the turbine—in other words, upon the momentum of the water column affected by opening or closing the gates, being smaller for low heads and short penstocks and greater for high heads and long penstocks. The sensitiveness of a steam-turbine governor may be greater than for a waterwheel governor, unless the head is very low and the conduit short.

When operated on base load, the regulation need be only such as to prevent injurious overspeed on dropping of load. For peak-load operation, taking the swings, an inherent speed regulation of 2 to 3 per cent is considered by some companies to be necessary for satisfactory frequency control. For base-load operation a regulation of 4 per cent to 5 per cent is found satisfactory by the same companies. For small stream-flow plants connected into large systems and not directly connected to a load, the inherent speed regulation is relatively unimportant.

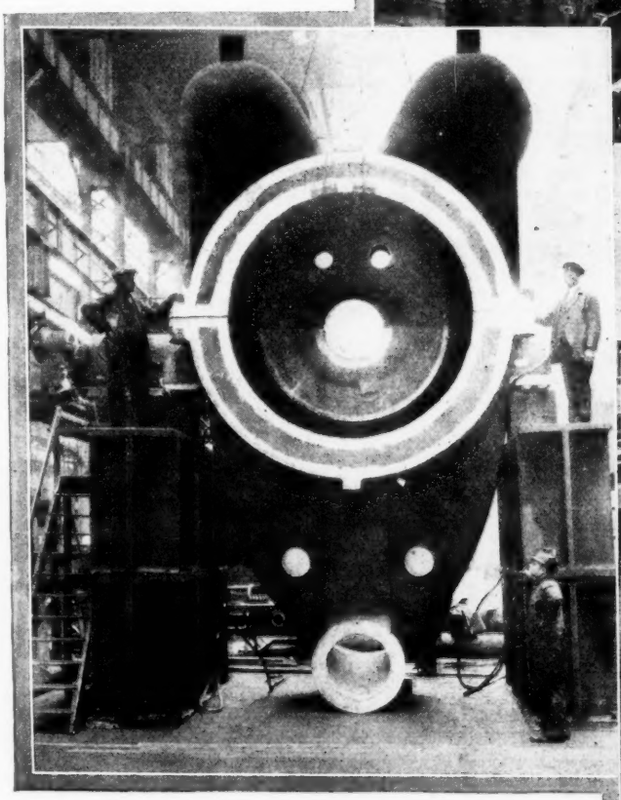
A riveted joint having a single cover plate is only equivalent to two lap joints near together and has no advantage in strength or durability over a lap joint, as the plates are subjected to the same bending action that is likely to produce cracking and leakage where the bending is most severe. As in a lap joint the rivets are subjected to tensile as well as shearing stresses and there is the disadvantage of requiring construction of two joints in place of one.

Largest Tandem Compound Turbine Under Construction

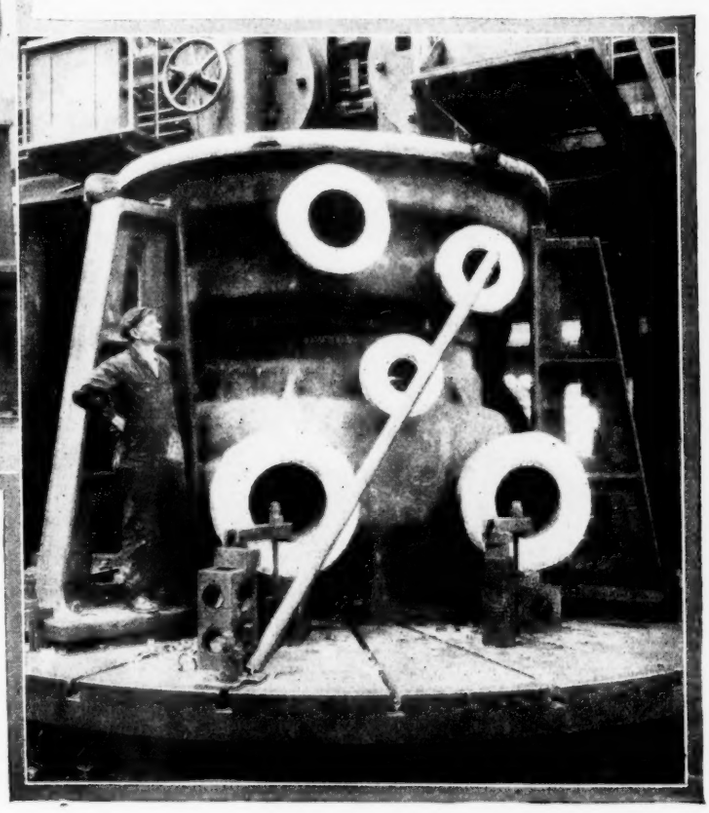
TWO of these giants of 94,000-kw. capacity, 103 ft. long and weighing 825 tons, are being built for the Southern California Edison Co. The main 90,000-kw., 16,500-volt generator exceeds in capacity and physical dimensions any electric generator previously built. Provision has been made for the use of gas for generator cooling. The double-flow low-pressure element exhausts into four vertical condensers. The views show the machine in the course of construction at the General Electric Co. shops.



Above—Eight hours are required to cut two slots in this generator field weighing 104 tons. Two slots are cut at the same time on opposite sides of the shaft



Above—The low-pressure hood of the high-pressure element weighs 35.3 tons and has a total height of 24 ft. 7½ in.



Right—Built in one piece and weighing 41 tons, this high-pressure cylinder stands 10 ft. high on the boring mill

Operating Methods in a Large Cold-Storage Plant

Control of Temperatures—Measuring Apparatus—Operation of Compound Compressors—Use of Clearance Pockets

By F. P. MACNEIL

IN THE operation of one of the largest New York City cold-storage plants there are some features that should be more generally adopted in the average refrigerating installation throughout the country.

The manipulation of the liquid refrigerant to gain the greatest amount of work for the power expended is accomplished by the use of intercooling, two-stage compressors with clearance pockets, and accurate instruments that record the temperature, pressure and quantity of refrigerant circulated.

The Venturi meter and recording temperature and pressure gages give continuous records of what is going on within the system, and it is by the aid of these instruments that the operating engineer is able to adjust the control valves properly.

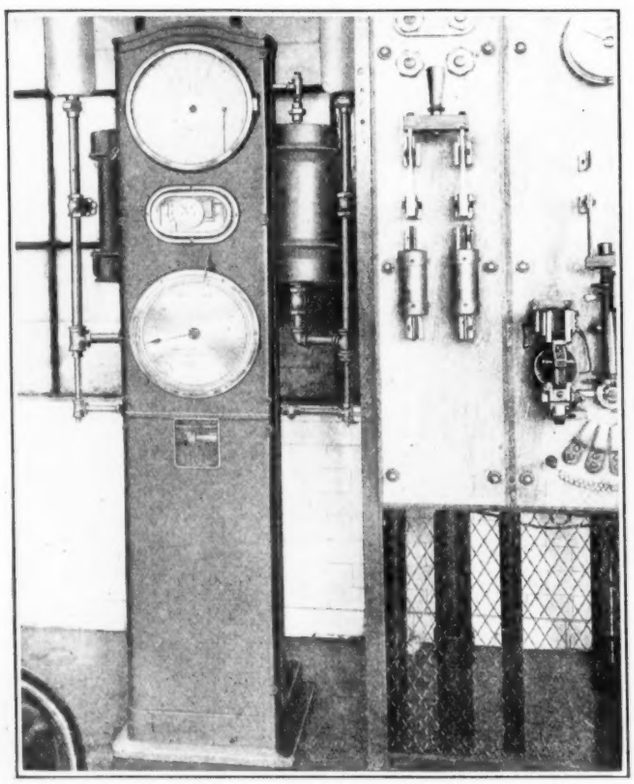
The Venturi meter, Fig. 1 and 2, can be made to operate with a high degree of accuracy, and in the adjustment of ammonia expansion valves the slightest movement of the valves is revealed by the record sheet of the meter. This device tells how these valves have been operated, and the engineer can easily see where the valves are too much or too little open, or just enough.

Venturi meters of this type have the liquid ammonia passing through the throat tube, which is inserted in the liquid line, but the pressure pipes, which indicate the fall in pressure due to the increase in velocity through the throat, are led to oil pots, where their pressure indications are transmitted to the oil, which in turn transmits the indications to the mercury manometer and the recording mechanism.

The Venturi meters operating on the brine and circulating water do not require that this precaution be taken, so brine and water are allowed to transmit their own pressures to the instruments.

As the meter is based on the phenomenon that a fluid in passing through a tapering contracted orifice, or throat, will have a portion of its potential energy of pressure transformed into kinetic energy of velocity, thus increasing the velocity at the expense of the pressure, a measurement of the fall of pressure at the throat indicates, on recording devices, the number of pounds, gallons or cubic feet of fluid passing through the throat.

The throat pieces, shown in Fig. 2, are proportioned for the conditions under which the meter is to operate,



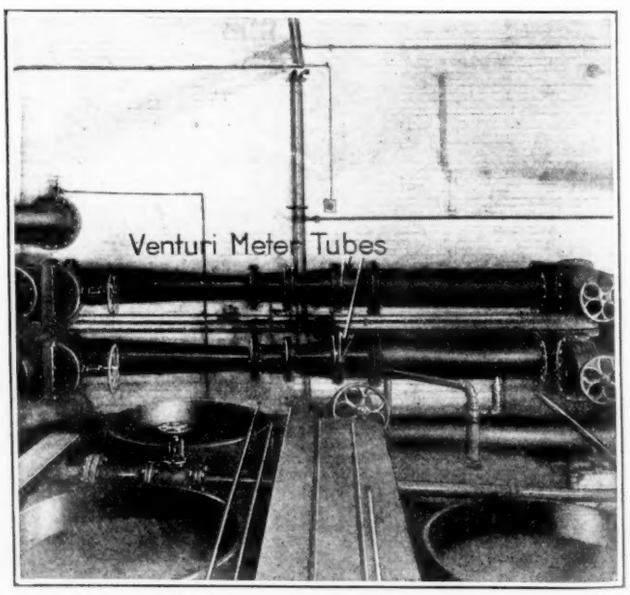


Fig. 1—Indicating and registering apparatus of a Venturi meter

Fig. 2—Throat pieces and connections of the meter

and the meter will register correctly over a liberal range. However, the meter cannot be made to operate correctly over a range far in excess or far below the value for which the throat is proportioned.

The brine and water meters will give the engineer instant warning of any irregularity of the cooling water or of the brine circuits.

If the brine begins to freeze and get slushy through being too weak for a low cooler pressure, it is manifested right away on the Venturi meter by a reduction in the gallons per minute. If the tide goes abnormally low or a strainer starts to choke on the circulating water, the Venturi shows the irregularity.

The recording pressure gages at all times show the slightest change in suction or in head pressure. The slightest irregularity in a line drawn by a pen on the chart of these instruments gives the engineer warning of impending trouble, and he is generally not slow in getting busy. He becomes so accustomed to knowing exactly how things should be under every set of conditions, that trouble has barely a chance to get started before he has it corrected.

Thermometers on the coolers, on the suction gas, on the condensing water, on the brine and on various other parts of the system show if he is getting the most refrigeration he can for the power input.

If the suction gas, arriving at the machine, shows a temperature far in excess of the temperature corresponding to the pressure in the cooler, he knows that the suction gas is being superheated excessively and proceeds to remedy this by bringing up the ammonia liquid level in the cooler as far as he can without priming. This reduces the number of exposed tubes carrying brine that tend to superheat the vapor as it passes between them after leaving the liquid level.

If the discharge gas from the high-pressure compressor shows abnormally high on the thermometer at the machine, he knows he is not expanding enough liquid ammonia into the intercooler to cool the suction gas to this cylinder low enough, or maybe he has not enough water going over the water intercooler. An inspection of the liquid level in the ammonia intercooler and of the temperature of the gas arriving at this cooler from the water intercooler, will generally tell him where the trouble lies.

The electric instruments reveals when the compressor is taking more power, and unless the engineer knows the reason for this increase, he proceeds to investigate and probably uncovers some trouble just starting or some condition not properly adjusted. The slightest change has to be accounted for.

The electric company sells power subject to certain conditions. The electric week begins on Monday at noon and ends the following Monday at noon. During this time the greatest amount of power taken by the plant over a period of fifteen minutes, is taken as the demand on the electric company. The amount of the power bill for the week is governed by this demand, so the engineer always endeavors to regulate his load so that the demand will be as low as possible.

There may be a lot of electric elevators working during the daytime, together with other electric apparatus that takes electric power, and as room doors are constantly being opened in the discharge or reception of goods, if the compressors are run at full power there will be a rather large demand. So the engineer runs

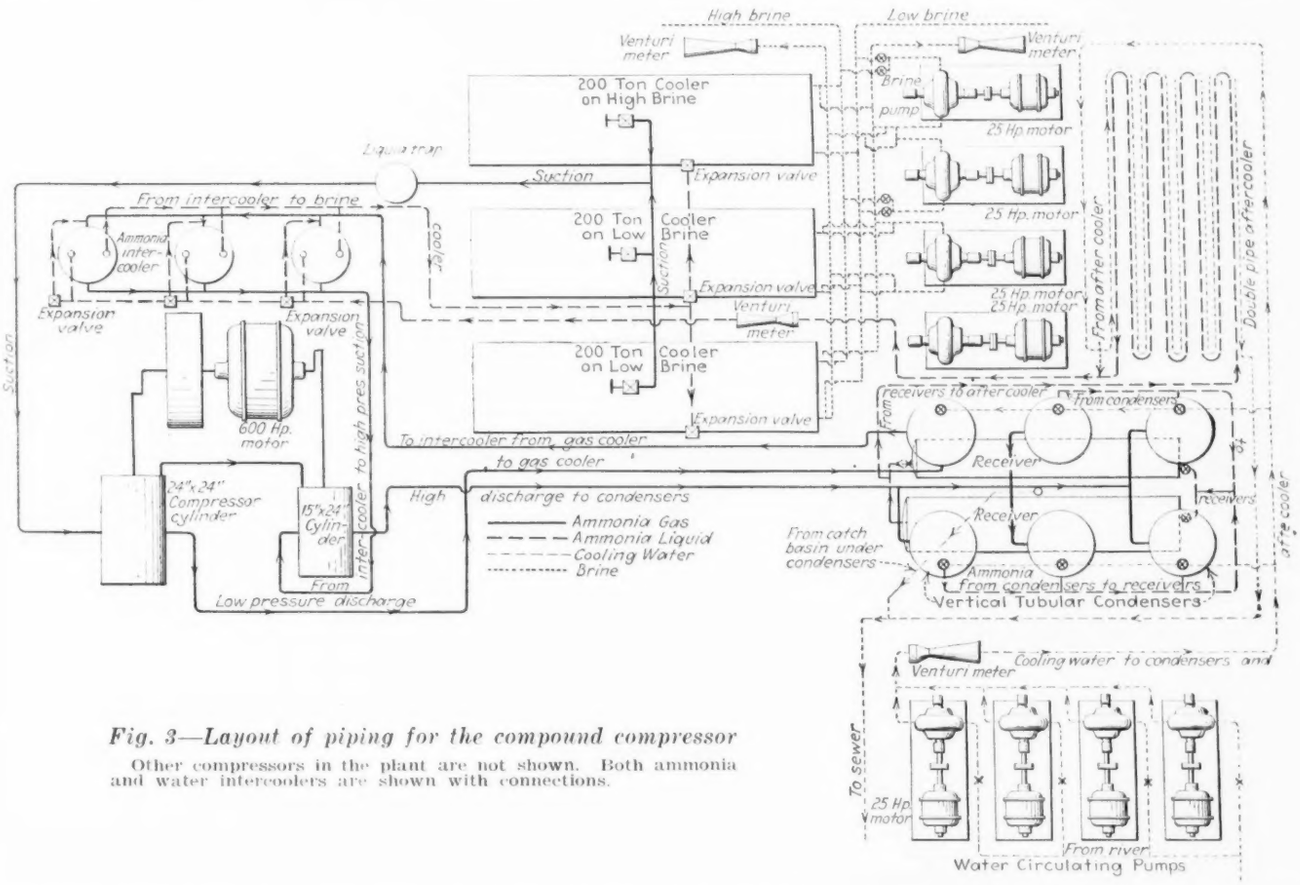


Fig. 3—Layout of piping for the compound compressor

Other compressors in the plant are not shown. Both ammonia and water intercoolers are shown with connections.

the compressors at reduced load by the aid of the clearance pockets, just enough capacity is used to keep temperatures from running excessively high during the day, and at night when the elevators are stopped and the rooms closed up, he proceeds to do most of the freezing, so the temperatures will be low at the start of another day.

As induction motors have a poor starting torque, and as they increase the inductive load the electric companies have to handle, with a consequent poor power factor, the use of the synchronous motor for compressor drive is now generally recommended.

There are times when the full power of the compressor is not wanted, and as the motor operates at a constant speed, the use of clearance pockets has come into vogue. These pockets are proportioned so that they are a certain percentage of the volume of the compressor cylinder and may be shut off from the cylinder at will by handwheels extending through the head-end cylinder cover, in which the pockets are located. In some cases three pockets are provided. The first one will contain a small percentage of the cylinder volume, the next one double that amount and the third one double the amount of the second one.

If one of these pockets is kept opened during the compression, some of the gas is crowded into the pocket and will not be discharged through the discharge valves. When the piston begins to return on the suction stroke, this gas comes out of the pocket into the cylinder and proceeds to fill the cylinder by expanding, thus creating a pressure in the cylinder in proportion to the size of the pocket that is open with the result that the cylinder will not draw in as much gas as it would if the pocket were closed. If it is found that the compressor is still pumping too much, the next larger pocket is opened and the smallest one closed. If the compressor still has too much capacity, the smallest pocket is opened again, there being two pockets open now with a combined volume three-quarters of what the largest pocket has. If this latest change does not prevent the compressor from pumping too much, the large pocket is opened and the two smaller ones closed.

It is sometimes better economy to transfer the load to a smaller machine if the pockets have to be kept open constantly, for while the compressor does take less current to drive it with the pockets open, still greater economy can be effected by loading a smaller machine to its rated capacity, by reason of the lower mechanical efficiency of the large compressors when operating at a low volumetric efficiency.

The Brine System

In the plant under consideration there are 1,180 gallons of brine at a temperature of —15 deg. F. per minute circulated. This brine returns to the coolers at a temperature of —12 deg. F. There are also 600 gal. of brine circulated per minute at a temperature of +12 deg. F., this brine returning to the coolers at a temperature of +15 deg. F. There are three 200-ton brine coolers installed, of the horizontal shell-and-tube type, and the brine makes a number of passes through the coolers before it enters the main leading to storage rooms. The layout of the plant is shown in Fig. 3.

There are four brine pumps of the centrifugal type driven by four 25-hp. motors. One of these pumps is kept on low-temperature brine, and one on high-temperature brine. The former pump works against a head of 95-lb. and circulates 1,180 gal. per min., while the latter pump works against a head of about 85 lb. and circulates around 600 gal. per min. Cross-connections make the four pumps available for any brine duty.

There are Venturi meters on both brine mains. A 75-per cent chloride of calcium brine is used throughout the system, and the brine thermometers are read to a tenth of a degree.

The suction vapor passes on its way to the compressor through a large suction trap, where any liquid entrained with the vapor is deposited. As this liquid trap may accumulate considerable liquid ammonia within its lower portion, due to the coolers priming, a motor-driven liquid ammonia pump is attached, so that this liquid may be pumped back to the receivers. As this liquid has done no work and represents a dead loss for the power consumed to handle it, the engineer is always on the lookout that the coolers do not prime.

Throttling the high cooler so that its pressure drops to that of the low-temperature suction saves resorting to a booster on the low suction main to bring it up to the pressure of the high main, before bringing the gas to the compressor. If the high cooler were performing a great amount of work, a booster would have to be used or resort had to multiple-effect compression, as a great quantity of high-pressure vapor being discharged from the high cooler into the low-temperature main would seriously affect the working of the low-temperature cooler.

Compressor Action

The gas is now compressed in the low-pressure cylinder from a pressure of 2.1 lb. to 38 lb. gage, and a temperature of 162 deg. F. at the machine. From the machine the gas is led to one of the condenser units, used as a water intercooler. Here the gas is cooled from a temperature of 162 deg. F. down to around 97 deg. F., depending on the amount of water passing over the cooler. From this cooler, as shown in Fig. 3, the gas is led to the ammonia intercooler, where, just as it is about to enter, it is met by a spray of liquid ammonia from an expansion valve placed in the elbow of the pipe on the side of the cooler. As this cooler is kept half full of liquid ammonia and together with the water intercooler is under a pressure of 38 lb. gage, the vapor leaving the liquid would be at a temperature of +24.1 deg. The coil within this intercooler is only half submerged in the ammonia, and ordinarily the exposed upper half takes heat from the gas coming from the water intercooler at a temperature of 97 deg. F., as the liquid within the coil has just been cooled to 50 deg. in the aftercooler before it entered the coil. The liquid vapor passes to the suction side of the high-pressure compressor at a temperature of from 42 to 48 deg. F.

The plant is equipped with more condensing capacity than needed, so that condensers may be cut out and cleaned, while clean ones kept in reserve take their places. All apparatus where oil collects, such as coolers, receivers, condensers, etc., are piped up to an oil-purging system, whereby these units may be cleared of oil and the oil reclaimed for use again. Pump-out lines to all sections of the plant are installed, with a pump-out machine. The discharge from all safety valves is taken care of by another system of pipes. Cooling water and lubricating oil have their own distinct piping. The use of different colors on these various pipes enables the engineer to know at a glance what duty a pipe or valve is performing. The system is kept clear of foul gases by an approved device.

Power Factor Simplified—
What Inductance Is and Its Effects in Electric Circuits

PROBABLY no other element in electric power generation and distribution has received as much attention as power factor. Notwithstanding all that has been written on this subject and the many attempts to explain in a simple way what it is, power factor still remains somewhat of a mystery to many operating engineers and electrical workers, who are not familiar with the fundamental principles that apply to electric circuits. Without these fundamentals, power factor cannot be understood. Therefore, in this article effort will be made to give an explanation of what happens in an electric circuit when the value of the current is changed.

A GOOD many attempts have been made to explain, by mechanical analogies, what power factor is, but most of these have not accomplished what they were intended to. In this and other articles to follow, an explanation will be given, based on a few simple electrical and magnetic fundamental principles and these compared with commonly understood fundamentals in mechanics. In this way it is hoped to give the reader a clear conception of what the power factor of an alternating-current circuit is.

One feature that is frequently overlooked is that the same laws apply to starting or stopping an electric current that apply to putting a body into motion or bringing it to rest after it is in motion. A body at rest cannot be put in motion instantaneously no matter how small it may be. Even a speck of dust will require a certain time to be put in motion from a state of rest. Likewise, it will require time to bring this speck of dust from a state of motion to a state of rest. This time, it must be admitted, is infinitesimal, but it nevertheless exists and is based on natural laws.

With heavy bodies the time required to put them in motion or to bring them to rest is easily measured and is evident in the handling of heavy machinery. If an engine with a heavy flywheel is stopped too quickly, the flywheel and other parts of the engine may be wrecked, owing to the tendency that the moving parts have to remain in motion after they are in motion. On the other hand, machines may be wrecked by attempting to accelerate them too rapidly—for example, a motor connected to its load through a chain drive. If power is applied to the motor quickly, it may start so suddenly as to break the drive or parts of the machine it is driving, owing to the tendency that the machine has to remain in a state of rest when at rest. The property of a body by which it tends to remain at rest when at rest and in a state of motion when in motion, is called inertia and bears a definite relation to the weight of the body.

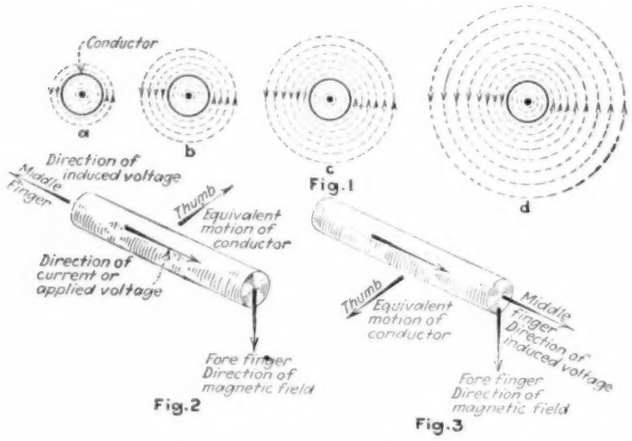
The property of inertia that is associated with all matter is also present in an electric circuit and is called inductance. It has been stated that no body can be started or stopped instantaneously, neither can an electric current be started or stopped instantaneously. It always requires a certain period after the switch is closed for the current in the circuit to reach normal value. Conversely, it also requires a certain period for the current to come to zero value when the circuit is interrupted. This is evidenced by the spark that appears where the circuit is broken. If the current is small and there is little or no magnetic material in the circuit, the arc will be small. On the other hand, the interrupting of a heavy current is always accompanied by a large arc.

When an electric current is caused to change its value, a voltage is induced in the circuit that opposes the change. This voltage is due to the change in the value of the magnetic field. When the current is building up in the circuit, the magnetic field increases in value and moves across the conductor in such a way as to generate a voltage that opposes the applied voltage and delays the building up of the current in the circuit. If something happens in the circuit that causes the current to decrease, the magnetic field is decreased and the field is cut by the conductor in such a way as to generate a voltage that opposes the current's reduction. In other words, the induced voltage tends to keep the current flowing in the circuit.

The law governing self-induction in a circuit is indicated in Figs. 1 to 3. When a current is building up in a circuit, a magnetic field is set up about the conductors, which acts as if it emanated from the center of the conductor and expanded outward into space in concentric rings, as indicated by the dotted circles. For example, in Fig. 1 *a* could be considered the cross-section of a conductor carrying a small current, where *b* has a larger current, *c* a still larger and *d* carrying more than *c*. The arrows on the lines of force indicate their direction, which in this case would be for current flowing toward the reader. On the left-hand side of the conductor the lines of force emanate at the center of the conductor and move outward across the conductor to the left. This is the equivalent of keeping the field stationary and moving the conductor in a right-hand direction across the field and is the condition for generating a voltage, namely, a conductor cutting the lines of a magnetic field.

The next thing to determine is the direction of the induced voltage. The rule for this is shown in Fig. 2. The three arrows represent the thumb, forefinger and the middle finger of the right hand. It has already

been shown that as the conductor is stationary and the lines of force on its left-hand side expand from the center outward to the left, the equivalent of moving the conductor to the right is obtained as represented by the direction of the thumb, Fig. 2. On the left-hand side of the conductor the lines of force are downward, as indicated by the arrowheads, and are represented by the forefinger arrow in Fig. 2. With the equivalent



Figs. 1 to 3—Showing how a voltage is induced in an electric circuit with a change in current value

direction of motion of the conductor represented by the thumb and the direction of lines of force shown by the forefinger, the direction of voltage will be shown by the middle finger. The three fingers of the right hand are held at right angles as indicated by the three arrows in the figure. From the figure it is seen that the induced voltage opposes the applied voltage and will delay the building up of the current in the circuit.

When the circuit is interrupted, the magnetic field decreases with the current. At the same time it acts as if the lines contracted to the center of the conductor. In other words, the process of building up is reversed, as would be indicated by Figs. 1*d*, *c*, *b* and *a*. As the lines of force contract on the left-hand side of the conductor, they move from the outside to the center, that is, to the right. This is the equivalent of moving the conductor to the left across the field and is so represented by the thumb arrow in Fig. 3. The direction of

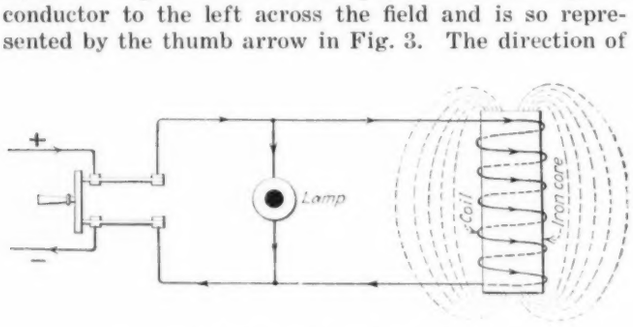


Fig. 4—Diagram of a coil connected to a source of direct current

the magnetic field is the same as when the current was building up in the circuit and is thus shown in the figure. Reversing the direction of the magnetic field across the conductor reverses the direction of the induced voltage so that it opposes the reduction of the current in the circuit.

From the foregoing it is evident that when the current increases in a circuit, the increasing magnetic field about the conductors induces a voltage in the circuit that opposes the change. Also, when the current decreases, the decaying magnetic field induces a voltage in the circuit that tends to keep the current flowing.

In Fig. 4 a coil on an iron core is shown connected to a source of direct-current. When the switch is closed, as previously stated, the current does not instantaneously reach normal value, but gradually builds up. During this period of building up the energy transmitted to the coil is being used in two ways. One of these is to heat the coil, and the other to magnetize the iron core. After the current reaches a constant value, all the energy represented by the current and volts is used in heating the coil.

Fig. 5 shows how the current builds up in the circuit. At the instant of closing the switch the full line voltage is applied to the coil and the current begins to increase in value. This causes a magnetic field to build up around the coil. In building up, this field is cut by the turns in the coil and generates a voltage that opposes

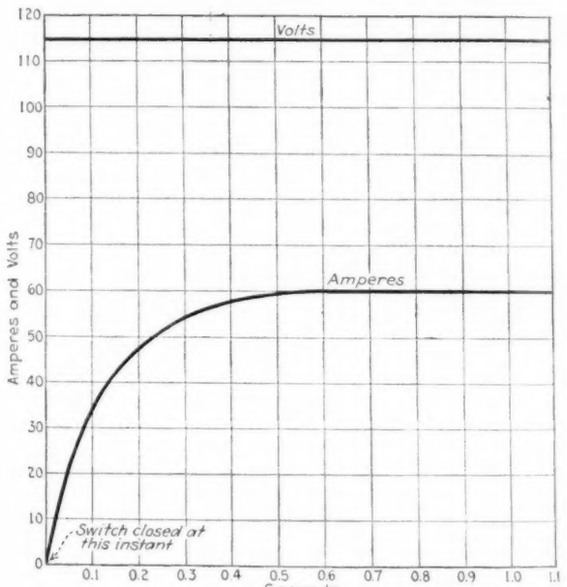


Fig. 5—Curve shows how the current builds up in a circuit

the applied voltage and delays the current in reaching normal value, as determined by the line volts and the resistance of the circuit.

In Fig. 5 the time required for the current in a certain circuit to reach normal value is shown to be about 0.6 sec. In circuits consisting of incandescent lamps the time would be less than this, while the current in the coil of a large magnet might require several seconds.

The power (watts) expended in a circuit is equal to the product of the volts and amperes and also to the product of the amperes times amperes times the ohms resistance in the circuit. For example, in Fig. 5, it is assumed 115 volts are applied to the circuit, which has a resistance of 1.917 ohms; then the normal current in amperes will be $115 \div 1.917 = 60$, as indicated by the current curve. From the product of the volts and amperes the watts equal $115 \times 60 = 6{,}900$ and from the current and resistance the watts equal $60 \times 60 \times 1.917 = 6{,}900$. In this case either method gives the same answer, which is as it should be.

Assume that after 0.2 sec., as shown in Fig. 5, the current reaches a value of 47 amperes. This current is obtained with 115 volts applied to the circuit, so that the watts delivered equal $115 \times 47 = 5{,}405$. The watts expended in the coil are equal to the square of the current in amperes times the resistance, or $47 \times 47 \times 1.917 = 4{,}235$. This calculation shows that at the instant when 5,405 watts are being delivered to the circuit, only 4,235 are expended in the coil. The difference, $5{,}405 - 4{,}235 = 1{,}170$ watts, is being expended to magnetize the circuit and this energy is stored in the magnetic field.

If the circuit is interrupted, the magnetic field will collapse and give its energy back to the system either by maintaining an arc at the switch when it is opened or in other ways. As an example, if a lamp is connected across the terminals of the coil and the switch is opened as in Fig. 6, the lamp will remain lighted for a period after the switch is opened. On a heavy coil with an iron core, if the switch is opened quickly the voltage developed at the lamp's terminals may be sufficient to destroy the lamp or even destroy the insulation on the coil.

We have in the foregoing a condition analogous to starting a machine with a heavy flywheel. If the energy delivered to the machine is measured during the period of starting and attaining normal speed, it will be found to be considerably more than actually required to drive the machine. The difference between that delivered to the machine and that required to drive it is stored in the moving mass. After the power is disconnected from the machine, it will continue to run until the energy stored in the moving parts is absorbed in overcoming friction and in other ways.

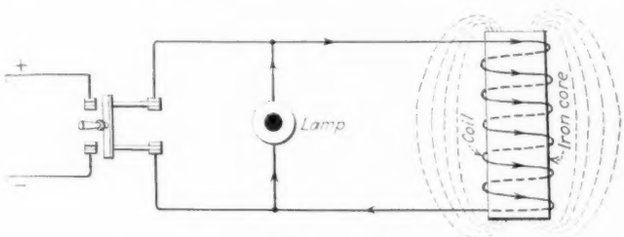


Fig. 6—Showing how current will continue to flow in the circuit for a short period after the switch is opened

If an attempt were made to stop the machine suddenly, it might result in the destruction of some of its parts, just as quickly interrupting an electric circuit might result in destroying the insulation. An example of what happens when an attempt is made to stop a heavy mass quickly, is found in the case of a steam engine when a slug of water comes over into the cylinder. The water is jammed in between the piston and cylinder head and, as the water is practically incompressible, the moving mass must stop or something break. The latter is generally the case—either the cylinder head, the piston or other parts give way.

What has already been said has had to do with direct-current circuits, and the effect of inductance is experienced only when a switch is closed or opened or when the value of the current changes in the circuit for any other reason. These changes are of such infrequent occurrence that they have little or no effect in the system, so much so that in direct-current systems the effects are neglected for most practical purposes. In an alternating-current circuit where the current is reversed many times a second, the effects of inductance become an important factor in the operation of such systems, as it takes place with each reversal of the current. This will be made the subject of the next article.

What Do You Know?

HOW much does an engineer know of engineering? One may understand all about combustion, but if he is shy on turbine dope, he can hardly claim the broad title of "Engineer." The 10 questions below are part of a quiz on your knowledge—can you make 100 per cent or 50? Your answers should be checked with those on page 710.

Ques. 1—What station in the United States has the highest-pressure boiler in operation?

Ques. 2—Who first suggested the gas-engine cycle usually called the Otto four-stroke cycle?

Ques. 3—Who is credited with building the first unidirectional, or uniflow, engine?

Ques. 4—Where should the fusible plug be located on a horizontal tubular boiler?

Ques. 5—In what plant is the largest steam boiler ever built?

Ques. 6—What causes a safety valve to chatter?

Ques. 7—What is meant by "balanced draft?"

Ques. 8—Who built the first commercial stoker in America?

Ques. 9—How can one determine if feed water contains oil, without an expensive test?

Ques. 10—On a three-wire two-phase system are the three wires the same size?

ACCORDING TO THE COMPRESSED AIR SOCIETY one should use only enough oil to furnish lubrication; that is, only enough to keep the cylinder walls and valves of an air compressor just greasy, neither dry nor wet. The oil is neither burned, vaporized nor washed away. Therefore, a small quantity of the correct oil will maintain the necessary film whose prime function is to assure a piston seal. With the correct high-grade lubricant in use, the presence of any deposits on the valves means only one of two things—either too much oil or the intake air is dirty.

Why the Panama Canal Bought Diesels

Reasons a Diesel Stand-by Was Preferred over Steam—Safety Features of the Plant—Engine Dimensions—Surprising Test Results

ON JANUARY 23, 1925, the Panama Canal Commission placed a contract for three direct-connected Diesel generating units of 2,500-kw. capacity each. In a period of about two years these three engines were designed, built, completely erected, tested, accepted, shipped and erected at the Canal. Two engines are now in service and the third is almost ready. Each engine had to be handled as a separate unit, completely erected on a permanent foundation in the builder's works, operated thereon and pass final inspection test before shipment could be made. These three units are of the six-cylinder, two-stroke-cycle, single-acting air-injection type, having cylinders of 29-in. bore and 44-in. stroke, operating at 125 r.p.m. and are direct connected to 3,125-kva. 2,200-volt 25-cycle flywheel-type generators, with direct-connected 45-kw. exciters. The power required to operate the locks of the Panama Canal is ordinarily supplied by a hydro-electric plant located at the Gatun Spillway. To guard against lack of water supply during the dry seasons or a breakdown of the transmission line, some form of stand-by service is necessary. Heretofore this has been furnished by the Miraflores steam station, consisting of an oil-fired boiler plant and three 1,500-kw. turbines, Miraflores being the distributing point for power for the Pacific Locks.

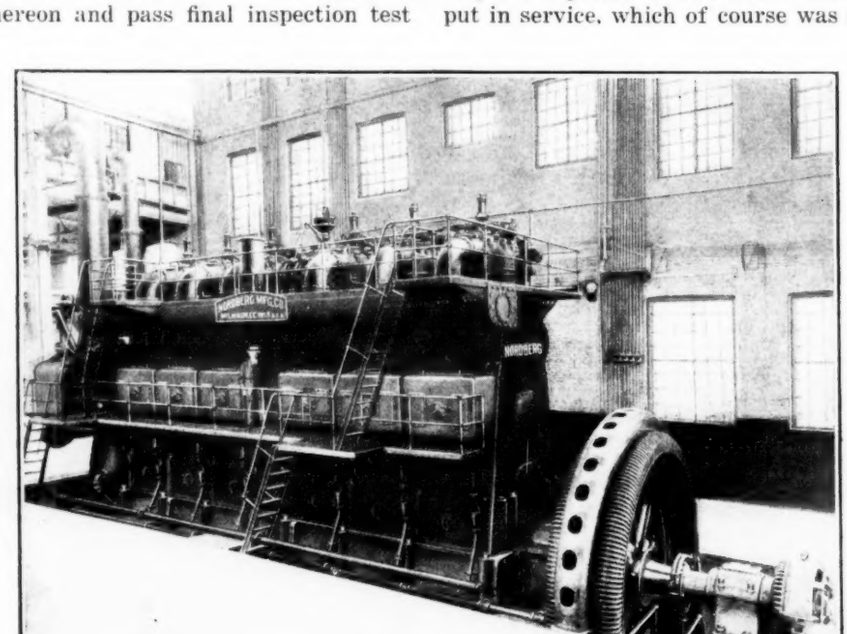


Fig. 1—The 3,750-hp. Diesel tested

After it had been decided to install a new stand-by plant, two principal questions had to be decided—location and the type of power unit. In the selection of the type of power unit three plans were considered:

The plan of building a hydro-electric plant at Miraflores, consisting of two 1,000-kw. units and operating on water drawn from the Miraflores Lake, was first considered. This had the advantage of cheapness, but presented a serious objection owing to the shortage of water during four months of the year, consequently, it was rejected.

A combination of hydro-electric and steam plant was next studied. It was planned to use water power during the rainy season and use the steam plant when the hydro-electric plant could not carry the load. To pick up this load instantly, would mean that a full head of steam would have to be carried at all times, which of course meant the burning of a considerable amount of fuel even though no power was being developed. If the boilers were cold, all Canal activities would have to stop for a period of two hours until the plant could be put in service, which of course was out of the question.

The next type of unit considered was the Diesel engine, which had none of the objections of the other two. It could stand idle for months without requiring fuel, yet be ready for service on a moment's notice. In fact, while on test in the builder's plant it was found that an engine could be started and a load of 2,500 kw. applied in 32 seconds. Consequently, a contract for Diesel units was placed with the Nordberg Manufacturing Co. The new power plant at Miraflores is pleasing from an architectural viewpoint, being of concrete construction built around a structural steel frame with inside dimensions 78x135 ft. The engines are placed with shaft centers 27 ft. apart and 15 in. below the engine-room floor. The distance from the floor to the lower side of the roof trusses is 45 ft. 6 in.

The basement, which has a headroom of 13 ft., contains the auxiliaries, including the fuel and lubricating oil equipment, pumps, auxiliary air compressor, etc.

Concrete mufflers with concrete stacks extending for a considerable distance above the roof are provided for each engine. A water spray at the muffler entrance cools the exhaust gases and keeps the muffler temperature low. The water level in the muffler is kept constant, but should it rise, a float-operated warning bell notifies the operator.

The general design and the principle of operation of these engines follow the customary Nordberg practice, there being, of course, some difference in the ar-

rangement and construction of the various details. They are of the full Diesel, air-injection type and operate on the two-stroke-cycle principle. Crossheads, water-cooled pistons and built-up crankshafts are used.

These engines must operate on a low-grade fuel oil known as "Bunker C," which is ordinarily carried in supply at the Canal. It will be seen that such a fuel permits of wide variation, as no mention is made of its specific gravity, heat value or restriction as to the sulphur content. At times it is known to be as heavy

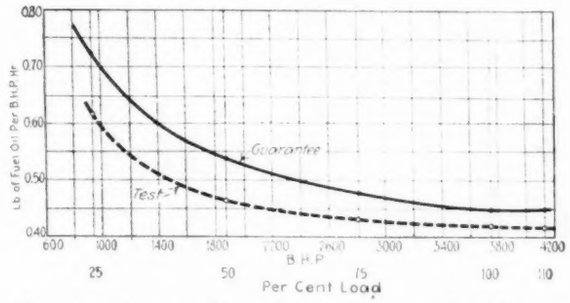


Fig. 2—Comparative test and guarantee figures

as 16 deg. Baumé. In order that such a heavy fuel can be passed through the fuel pumps, atomizers, etc., even at ordinary room temperatures, special heating appliances must be provided.

Fuel Treatment

The oil is obtained from the Balboa oil farm and pumped to a storage tank on a hill at the rear of the power plant. It then flows by gravity to the basement and passes through a coil immersed in a water bath which is warmed by thirty 1,000-watt heaters, in order that water and solid foreign matter may be more readily removed by the centrifuges. The temperature of these heaters is automatically controlled by a thermostat. After leaving the centrifuges, the oil is discharged into a service tank having a float control to maintain a constant fuel supply at the engine. This tank is also provided with a heating coil to raise the temperature of fuel if desired. A motor-driven pump then transfers the fuel to a small supply tank on the overhead platform of the engine. This tank has a heating coil, thus keeping the fuel heated until it is delivered to the fuel valves. Hot water discharged from the exhaust manifold is used as the heating element in the last two heaters. Means are provided for regulating the amount of water passing through the coils, thereby maintaining a temperature best suited for any particular fuel.

All the air used for scavenging and fuel injection is filtered by being passed through air filters before going to the scavenging pumps and air compressors. A battery of thirty filter sections is placed in the duct taking from outside the building, while four are placed in the tunnel taking air from below the generator. This latter battery serves to ventilate the lower half of the generator. By the use of these filters all grit and abrasive material in the air is removed, thus reducing wear and lengthening the engine life.

The main cooling-water supply is taken from Gatun Lake through a 20-in. main connecting with a header running the full length of the basement. In order to prevent silt and marine growths getting into the jackets or clogging other parts of the cooling system, the water is filtered through several layers of sponges. These are known as Luffa sponges, a gourd-like vegetable growth common in that locality and prepared for use by taking off the rind, removing the seeds and curing the remaining fibrous material. The pressure in the header being insufficient to force the water through the jackets, a motor-driven centrifugal pump in the basement is used to give the required head.

An auxiliary water supply is also provided in case the main supply should fail. This is obtained from a connection with the treated water main that runs from the Miraflores filtration plant to Balboa.

To guard against damage should either the cooling water or lubricating oil supply fail, provision is made to shut the engine down quickly by the installation of suitable automatic devices. Should the pressure on the cooling water or that of the oil in the pressure system drop below normal, the fuel to the cylinders is cut off and the engine automatically stopped. Trials showed that when carrying full load this was accomplished in 27 seconds and 100 seconds on no load.

Some of the principal engine dimensions and weights are:

Over-all length, engine only	48 ft. 6 in.
Over-all length, engine and generator	61 ft. 6 in.
Width of bedplate	11 ft. 0 in.
Height of engine above floor	21 ft. 0 in.
Over-all width	16 ft. 3 in.
Main bearing, diameter	19 in.
Crankpin bearing diameter	19½ in.
Crosshead-pin bearing diameter	12 in.
Weight of engine only	815,000 lb.
Weight of engine and generator	1,000,000 lb.
Weight of crankshaft	90,000 lb.

The complete testing of those engines before shipment was in itself a very extensive undertaking, involving the construction of a foundation similar to that on which the engine generator units complete will be

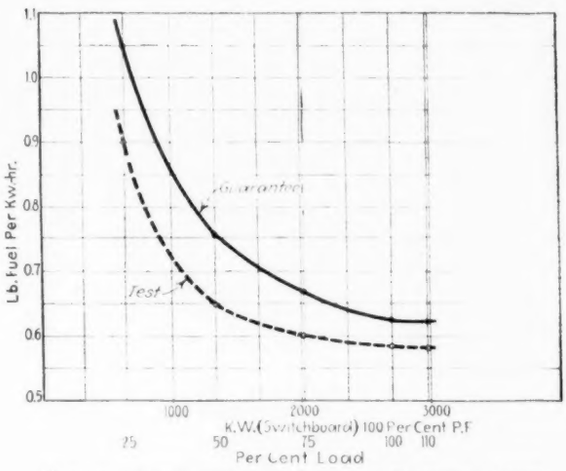


Fig. 3—Fuel consumption per kilowatt-hour

mounted in the power plant on the Canal. Because of the cost and space required, only one such foundation was considered feasible at the builders' works, so it was necessary to erect, test, disassemble and ship one unit at a time before the erection of the subsequent units could proceed.

It is worthy of note that in spite of their unusual size all three engines passed their required acceptance test without serious trouble, easily surpassing the contract guarantees in every respect. The only disturbing feature that developed was during the preliminary running of the first engine, when it was noticed that it was subject to a slight torsional vibration at a speed of approximately 138 r.p.m. This was so close to the

designed speed of 125 r.p.m. that it was decided to eliminate the possibility of running into the critical when changing loads by making a change in the shaft so as to raise this critical to a value well above the speed range of the engine. This involved the increase in the size of shaft from the No. 6 cylinder outward, also a change in the generator rotor to accommodate this larger shaft. These changes of course caused considerable delay in the testing of the first unit, but the results were entirely satisfactory, the disturbing critical being raised approximately to 165 r.p.m. The second and third engines were built with these changes incorporated, and as a result they operated satisfactorily from the start.

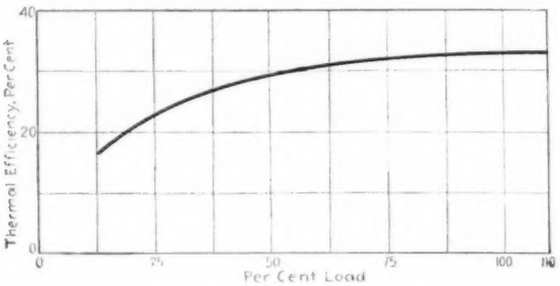


Fig. 4—Variation of thermal efficiency

The loading of the generators was accomplished by means of a large water rheostat, receiving current directly from the generator at 2,200 volts and arranged to provide accurate load balance between the three phases by individual adjustment of the plates. The same procedure was followed in the test of the three engines, involving a continuous operating test period of 20 hours subdivided as follows: 2 hours at no load; 3 hours at 25 per cent load; 4 hours at 50 per cent load; 5 hours at 75 per cent load; 5 hours at 100 per cent load, and 1 hour at 110 per cent load.

Intervals of 30 to 45 minutes were required between the various load periods for adjustment of the load and to permit the various temperatures and pressures to acquire a fairly stable value so that the actual continuous operating period was approximately 24 hours.

During the test runs, results of which appear in the table, necessary temperature and pressure readings were taken every ten minutes, observations being made by engineers of the manufacturer and by students from the Milwaukee School of Engineering under the supervision of Panama Canal inspectors. Water meters were installed in the several cooling-water branch lines in order to determine accurately the distribution of total supply to the various points, quantity readings being taken every ten minutes. Exhaust-gas temperatures were indicated by a pyrometer with a thermocouple at each cylinder exhaust outlet. Indicator diagrams were taken every 15 minutes from the power cylinders. Fuel oil was measured continuously by batch weighing, so that all oil used by the engine throughout the test period was included in the readings taken, and figures hereinafter recorded represent an average value for the test period. An exhaust-gas analysis for each load period was made with a standard Orsat apparatus. The motor-driven circulating-water pump, lubricating oil pump, fuel-oil service pump and the centrifuges consumed approximately 43 kw., this power being charged against the engine in all test result computations.

A comparison of fuel consumption guarantee and the actual consumption as determined by the test is of interest. These are shown in Figs. 2 and 3 plotted with reference to horsepower and kilowatts respectively. It will be noticed that the test figures are substantially lower than those guaranteed.

Of the many features that have gained prominence for the Diesel engine, the outstanding one is its high thermal efficiency. No other type of prime mover in which power is derived from fuel can equal or even approach it. The curve in Fig. 4 shows the work derived in comparison with that contained in the fuel in the form of heat.

The extremely flat economy curve shows a fairly high economy even at half load. At this point it required only 12,200 B.t.u. to produce a kilowatt, or 12.2 kw.-hr. to the gallon. It should be remembered, too, that these tests were made on engines that had seen very little service. After several months of service in the field and with the running friction reduced, it is but natural that better fuel consumptions can be secured than were recorded in these tests, and that these will continue indefinitely, with proper maintenance.

TEST OF 3,750-HP. NORDBERG DIESEL

Load, per cent	25.0	50.0	75.0	100.0	110.0
Duration of test, min.	180.0	240.0	300.0	306.0	66.0
Barometer, in Hg.	29.79	29.79	29.79	29.79	29.79
Pressure:					
Injection air, lb. per sq.in.	823.0	974.0	1,030.0	1,070.0	1,075.0
Cooling water, lb. per sq.in.	38.8	38.8	39.1	39.0	39.0
Lubricating oil, lb. per sq.in.	19.3	19.2	18.5	17.9	18.5
Scavenging air, lb. per sq.in	5.16	4.9	5.0	5.0	5.1
Temperature:					
Atmosphere, deg. F	76.0	81.9	80.5	79.0	75.4
Cooling-water inlet, deg. F.	64.0	61.9	58.0	57.0	56.0
Jacket outlet, deg. F.	128.4	127.5	129.1	134.8	134.7
Piston-cooling outlet, deg. F.	124.2	126.3	127.4	127.6	129.3
Lubricating oil to engine, deg. F.	84.2	85.7	84.1	83.0	82.0
Lubricating oil from engine, deg. F	99.5	101.5	102.5	102.1	103.4
Exhaust temperature, deg. F.	315.0	400.0	510.0	640.0	690.0
High heat value of fuel, B.t.u.	18,738.0	18,738.0	18,738.0	18,738.0	18,738.0
Baumé gravity of fuel at 60 deg.	20.6	20.6	20.6	20.6	20.6
Viscosity at 122 deg. F., sec.	47.0	47.0	47.0	47.0	47.0
Viscosity at 86 deg. F., sec.	180.0	180.0	180.0	180.0	180.0
Sulphur content, per cent	1.09	1.09	1.09	1.09	1.09
Fuel oil, lb. per hr.	584.0	871.0	1,218.8	1,585.6	1,728.0
Fuel oil, lb. per i.hp.-hr.	0.282	0.277	0.309	0.322	0.322
Fuel oil, lb. per b.hp.-hr.	0.618	0.462	0.431	0.422	0.417
Indicated hp. of power cylinders	2,663.0	3,150.0	3,945.0	4,925.0	5,360.0
Indicated hp. of air compressor	171.6	212.4	236.3	250.2	249.9
Indicated hp. of scavenging pump	387.5	385.0	376.2	386.0	395.0
Brake horsepower	943.0	1,886.4	2,823.0	3,759.6	4,143.1
Mean indicated pressure, lb. per sq.in.	37.28	57.1	71.45	89.57	97.4
Mean effective pressure, lb. per sq.in.	17.08	34.2	51.2	68.2	75.1
Mechanical efficiency, per cent	45.8	59.9	71.6	76.3	77.2
Thermal efficiency, per cent	21.9	29.4	31.5	32.2	32.6
R.p.m.	125.65	125.1	125.17	124.71	125.0

Lubricating oil:
Gallons to power cylinders per 24 hours, 1.5.
Gallons to scavenging pump and compressor per 24 hours, 0.5.
Average amount circulated through remainder of system, main bearings, crosshead, etc., 1,420 gal. per hour.

Why I Am Not Going To Modernize My Power Plant

PLENTY of talk is going around about this mill and that planning to spend a lot of money on what they call "modernizing their power plants." Even *Power* is conducting a prize contest for papers showing savings effected. But none of that for me. No, sir! I hope these plants get their money back, but I know they won't, and I've got my reasons. Yes, sir!

In the first place the power plant is a nuisance, always has been a nuisance and always will be a nuisance, so why make it a bigger nuisance by spending more money on it? Answer that if you can! It's all right for my engineer to tell me that the plant is out of date and that other mills are putting in high-pressure plants and saving money. That's his job and, of course, it looks big to him; it's all he sees, and he doesn't realize what very small potatoes the power end of the job really is. Why, in my mill the power cost is less than a quarter of the total cost of production, and any money I've got to spend is going to be spent on the big end of the job and not on the small end, where it's all going out and nothing coming in.

I told him this the other day, and all he could say was: "Well, Mr. Bliman, the capital you put into a new power plant would be returned in full by the savings you would make in three years."

Did you ever hear such nonsense? Of course, I treated him with contempt. It's no use arguing with these fellows; it only encourages them.

Then again, think of the enormous cost of a high-pressure plant. No, I haven't got prices on them and I don't need to. *It stands to reason that a four-hundred pound plant will cost roughly four times as much as a one-hundred-pound plant*, and I go by reasoning all the time, you can bet your life.

Another thing, think of the loss of production while we were changing over. Why, I daresay it would take weeks or months before we got to running right, if we ever did, and who would pay us for what we would lose, and how would we ever get our customers back? Of course, my engineer says there need not be any loss of production at all, and he has the nerve to tell me that he knows of mills that actually increased their production right away, but maybe they were lucky, and I never am. I take no chances on such ridiculous claims.

It's all too new, and I believe in well tried methods, even if some of these smart alecks say they are out of date. Those bright fellows don't know everything, not by a long way!

Suppose I did spend a whole lot of money and put in a new plant, just because some wise bird figures I can't lose; how do I know I should ever see the savings he reckons on? Would he make good my losses if I did lose? Like heck, he would!

Besides, I'd need a staff of specialists to run one of these new-fangled plants, and where do you suppose I'd get them? I've got a pretty good crew at present, and they manage to run my old plant well enough, but I don't figure they could run one of these new ones. My engineer says it would be easier to run a new plant with all modern conveniences than to try to get good efficiency by working in the dark with out-of-date equipment, but I'm not aiming to spend money to give him an easy time anyway.

Consider the danger there would be in living right by boilers carrying several hundred pounds pressure. The offices are well out of the way, but I'm thinking of the operating crew and the risk to their lives. Besides, I might be walking through the plant just at the moment it exploded. I've heard of boilers exploding at only sixty pounds pressure.

Of course, my engineer comes back at me with one of his usual alibis; he says that the plant would be designed to carry the high pressures safely, and that a bridge, for instance, designed for heavy loads is no more likely to fail than one for light loads. I never knew such a man for argument; there's no shutting him up. He says he has never heard of a real high-pressure boiler exploding. Plenty of time yet, says I.

Well, what it all gets down to is this. I got tired of arguing with this fellow all the time, and yesterday I put my foot down and told him I simply would not hear another word from him on the subject, and if he valued his job, he'd better watch his step. I guess he won't worry me any more, for a while at least. However, I suspect that some day I may have to give in a little against my better judgment, just not to be out of date.

Somehow or other I can't help liking that cuss. He hounds the life out of me, but, doggone it, he always seems to know what he's talking about, and I've never yet caught him lying or bluffing. That's what really has me worried. I just know that sooner or later he's going to worm the money out of me.

Nothing doing! How do I know I should ever see the savings?

How To Figure Power Required To Drive Fans

OFTEN the operating engineer is called upon to determine the size motor required to drive a fan and finds the calculations confusing. This explanation will help give a better understanding of the fundamental principles involved

BEFORE figuring the power required to drive a fan a considerable amount of preliminary work should be finished. The quantity of air to be handled and its temperature, the total head against which the fan is to work and therefore the friction losses in the duct system, should all be known or calculated. Assuming these data have been obtained, we can then look into the question of air horsepower and fan power requirements.

Air horsepower is the rate at which work must be done to move air against the required pressure head.

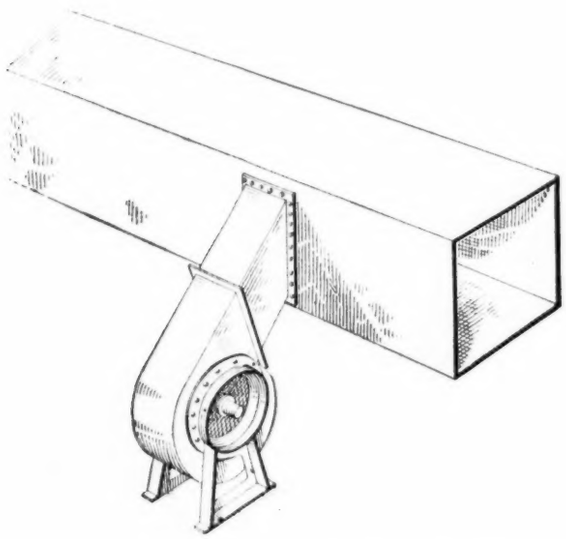


Fig. 1—Fan blowing air against a pressure of one pound per square foot

A fan does work on the air or gas it is handling in three ways: (a) In moving the gas against the total fan head; (b) by compressing the gas from the initial pressure to the final pressure, and (c) by increasing the velocity of the gas from its initial velocity to the final velocity. In fan practice the compression of the gas is very small, owing to the low pressure heads used, and the work of compression is usually neglected. The work done in increasing the gas velocity may also be neglected because the fan efficiency submitted by the manufacturer is based on the static pressure developed by the fan. It therefore includes the work done in increasing gas velocity. This static fan efficiency, as it is called, is lower than a true fan efficiency.

Fig. 1 shows a fan blowing air through an opening one foot square into a duct in which for convenience we will assume there is a pressure of 1 lb. per sq.ft., and neglecting friction this 1 lb. pressure is the total head against which the fan is working. In order to force air into the duct, the fan must exert a force on the air equal to the area of the opening in the duct times the pressure head, which in the assumed case is 1 sq.ft. times 1 lb. per sq.ft., or a force of 1 lb. It is evident, since the area of the opening is 1 sq.ft., that 1 cu.ft. of air must move one foot in entering the duct, and as the force required to push the cube through the 1 ft. distance is 1 lb., the work done is 1 ft.-lb. If the opening in the duct had been 2 sq.ft. instead of 1, the cubic foot of air would have had to move only one-half a foot to enter the duct, but the force required to move it would be 2 lb. and therefore the work done on the air remains $\frac{1}{2} \times 2$ or 1 ft.-lb.

Setting this procedure down in equation form we have, work = lb. per sq.ft. $\times$ area $\times$ feet, but area

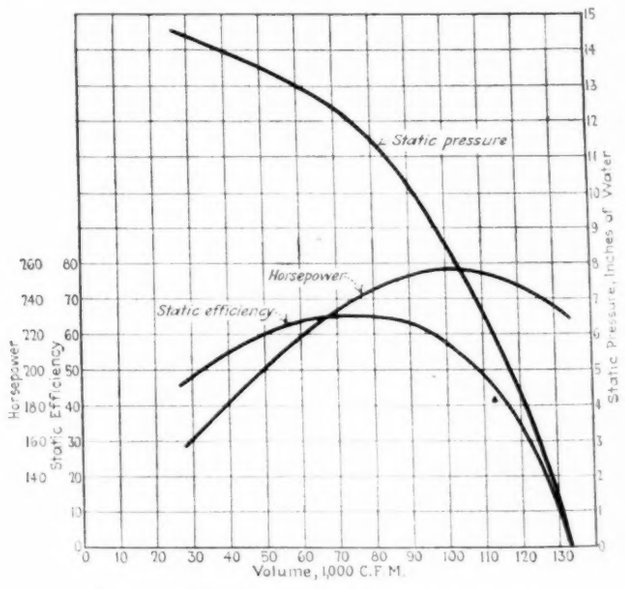


Fig. 2—Typical fan performance curves

times feet is the volume of air handled, so work = lb. per sq-ft. $\times$ volume, and is independent of the area of the duct opening. Work will become power if cubic feet of air per minute is substituted for volume, and by dividing by 33,000 ft.-lb. per min. horsepower will be obtained. Sometimes the quantity of air to be handled is given in pounds per minute instead of cubic feet. In this case it will be necessary to convert to cubic feet by dividing the weight per minute by the gas or air density.

The head, or pressure against which a fan works, is usually expressed in inches of water. A fan works against both an inlet and a discharge head which usu-

ally is a suction or negative pressure on the inlet side and a positive pressure on the discharge side. The total fan head is the algebraic difference between the inlet and outlet pressures. For example, if at the fan inlet there is a suction, or negative pressure, of 2 in. of water and a discharge pressure of 4 in., the total fan head will be 6 in. of water. The head in inches of water may be converted to pounds per square foot by multiplying inches of water by 5.2, which is the pressure exerted by a column of water one inch high.

The equation for air horsepower may now be written,

$$Air\ horsepower = \frac{W \times 5.2 \times h}{33{,}000 \times d}$$

Where W = Gas quantity, lb. per min.,
h = Total head, inches of water;
d = Density of gas, lb. per cu.ft.

The effect of gas density on air-horsepower is seldom fully realized. To illustrate, assume a fan blowing a constant weight of air into a duct system in which the pressure remains 2 in. of water. It is evident if the density of the air were halved owing to a temperature rise that the volume of air handled would be doubled and the air-horsepower would also be doubled. Since the density of a gas varies inversely as the absolute temperature, the power requirements of a fan handling a constant weight of gas against a constant pressure in inches of water will vary directly as the absolute temperature of the gas handled. Thus it is important to install a fan so it will handle the coolest gas possible.

Like all other machines a fan requires a power input greater than the power it develops. The ratio of the horsepower input to the air horsepower developed is the fan efficiency, which for a well designed fan may be as high as 65 per cent. In Fig. 2 are shown typical curves of efficiency, static head developed by the fan, and fan horsepower. The shape of the static head and horsepower curves will vary with fan blade design and the curves are illustrative only. The peak in the efficiency curve emphasizes the necessity of selecting a fan of correct size for the duty required. Generally, more than one size is available to satisfy the requirements and it is best to consult the manufacturers' tables before making a decision.

Assuming a fan of the proper size has been selected and the curve of fan efficiency has been obtained from the fan manufacturer, the power required to drive the fan may be computed by dividing the air horsepower by the fan static efficiency.

Safe Loads for Steel Floor Plates

By Charles F. Fessler

In modern power plants checkered or diamond pattern floor plates are used a great deal for walkways, platforms, coverings over pits and pipe trenches, etc.

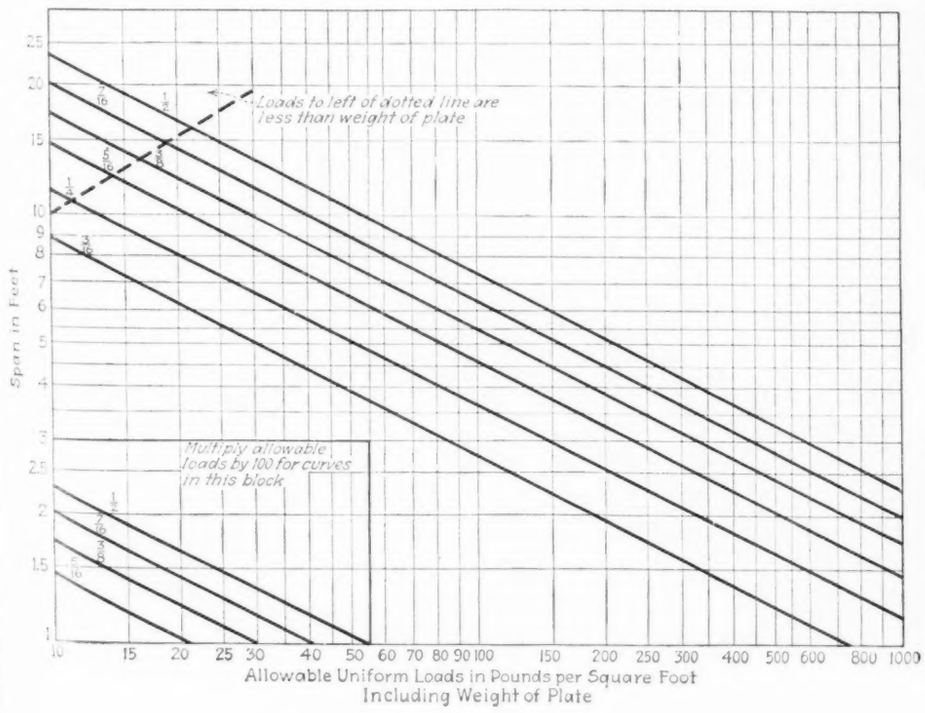
The accompanying diagram, showing the safe uniform loads for such floor plates of varying thicknesses, will prove a convenient time saver for anyone who has occasion to design or check platforms or other structures using steel-plate flooring.

The advantage of this diagram is that the user is able to find the loads for any given span at once, while the tables found in the various handbooks give the loads for spans of even numbers of feet only, and when interpolating for intermediate spans the results are likely to be approximate, especially for spans less than 4 ft., where the numerical values of the loads step up rapidly.

The curves in the block in the lower left-hand corner are continuations of the curves running off the right-hand side of the sheet, and the values given for safe loads are to be multiplied by 100 for the curves in this block only.

For loads concentrated at the center of the span, use one-half of the total safe uniform load. These curves are based on a fiber stress of 16,000 lb. per sq.in., but the safe loads for any other stress may be easily figured as explained in the caption of the diagram.

The maximum and minimum widths for various thicknesses of plates are given in the table in the upper right-hand corner, also the corresponding weights.


Span in Feet
Loads to left of dotted line are less than weight of plate
Multiply allowable loads by 100 for curves in this block
Allowable Uniform Loads in Pounds per Square Foot
Including Weight of Plate

Thickness	Width—Max. In.	Width—Min. In.	Weight, Lb. per Sq.Ft.
1/4	60	12	21.4
5/16	60	12	18.9
3/8	60	12	16.3
7/16	60	12	13.8
1/2	60	12	11.2
3/16	48	12	8.7

Loads for Checkered Steel Floor Plates (Carnegie)

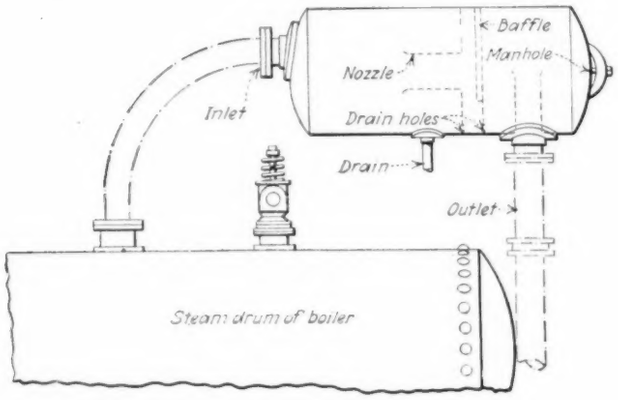
The curves are based on a fiber stress of 16,000 lb. per sq.in.; for any other fiber stress divide the load given by 16,000 and multiply by the desired fiber stress. The fractions represent plate thickness in inches.

Purifying Steam with a Separator

By C. E. Joos*

With the modern practice of operating boilers at high ratings, foaming and priming troubles are becoming more general. Wet steam is common in many plants where the boiler feed is principally makeup. The use of softeners, evaporators, etc., tends to reduce such foaming and priming, but even so, there are many cases where it still continues.

Recently, the management of a steel company experienced serious difficulties from foaming in the boilers of a water-gas plant. Priming was so severe that not only was the superheat reduced to 75 deg. F., but the superheater tubes became so choked with deposit that it was necessary to cut out and replace elements every



The separator keeps water and dirt out of the superheater

four days, which not only rendered maintenance arduous, but interfered seriously with operation.

These difficulties were overcome altogether by the installation of specially designed Cochrane receiver separators between the steam drums and the superheaters. As shown in the drawing, the shell of the separator is a horizontal cylinder. Steam enters at one end through an 8-inch inlet into an expansion chamber, which catches the greater part of the entrained moisture. It then enters an approach nozzle, which directs it against a specially arranged baffle designed to remove the more finely divided moisture.

It is found that less than half of one per cent of moisture remains in the steam after passing this baffle, when operating between 250 and 300 per cent of rated load. Since the separator was installed, it has not been necessary to replace a single superheater tube and no deposits have accumulated; in fact, the superheater tubes are in a more or less polished condition. The records show that a superheat of 150 deg. is now regularly obtained.

In order to determine definitely the performance of the apparatus, a test was run for several days, including determinations of moisture entering the separator, moisture leaving the separator, per cent of rating, water discharged by the trap draining the separator, etc. The test showed that at all times the separator delivered steam having less than half of one per cent of moisture.

By measuring the trap discharge it was found that when using river water containing approximately 5 grains per gallon of solids, the mixture entering the separator had a moisture content of 16 per cent. With well water the trap discharge was as high as 35 to 40 per cent.

The drop in pressure of the steam in passing through the separator, including the long-sweep elbow connecting it to the outlet nozzle on the boiler drum, was less than 0.8 inch of mercury at 250 per cent of boiler rating.

*Cochrane Corporation, Philadelphia.

A Check on Your Answers*

Ans. 1—Lakeside plant, Milwaukee, has a 1,350-lb. boiler, and Edgar station, Weymouth, has had a 1,200-lb. boiler in operation for two years and two 1,400-lb. units are being installed.

Ans. 2—Beau de Rochas, a Frenchman, suggested in 1862 the cycle that Otto adopted later.

Ans. 3—Jacob Perkins, early in the Nineteenth Century, patented the unidirectional-flow engine, but did not steam-jacket the heads.

Ans. 4—In the rear head and must be not less than 2 in. above the top row of tubes and should project through the sheet not less than ½ in.

Ans. 5—The Beacon Street heating plant, Detroit Edison, contains 41,000-sq.ft. boilers. See *Power*, Nov. 23, 1926.

Ans. 6—The blowdown ring is too closely adjusted, so that the valve closes at a slight pressure drop and opens at the following small rise in pressure.

Ans. 7—"Balanced draft" is a system of draft control whereby the pressure within the furnace is atmospheric, or in practice slightly below atmospheric.

Ans. 8—The earliest record of an American stoker is the underfeed stoker brought out by Frisbee in 1844.

Ans. 9—Mix caustic soda in a pail of the water. If oil is present, even in small amounts, it will saponify, or form soap.

Ans. 10—If the system is balanced—that is, the current in the two phases equal—the current in the common conductor is equal to the current in one phase times 1.414. This is the maximum value that can obtain. Therefore, if the common conductor is selected 0.4 larger than the outside conductor, it will meet all load requirements that can be supplied by the other two wires.

When Preheated Air Is Used to support combustion, it seems that the furnace temperature goes up about 100 deg. F. for an increase in air temperature of from 200 to 250 deg. F. With the hotter air combustion is more intense and the temperature of the fire-bed or flame is higher, but two things work together to keep the rise in the temperature of the furnace atmosphere from being as large as the rise in the temperature of the air supplied. The first of these is the increasing proportion of the heat liberated that is transmitted by direct radiation to the boiler, without increasing the temperature of the furnace atmosphere. The second is the fact that at high temperatures the specific heat of gases is greater than at low temperatures, so that a given contribution of heat will represent a larger temperature interval in the lower ranges than at temperatures approaching 3,000 deg. F.

*The questions of which these are the answers will be found on page 703.

Research on Intercrystalline Fracture Needed

EMBRITTLEMENT of boiler steel is still open to considerable question. While there is much evidence that the so-called caustic is apparently a contributing element in inducing early failure, there may be many other factors of importance. For instance, it appears from the work of one investigator that stress beyond the elastic limit of the material is necessary to induce failure. Another indicates that hydrogen penetration of the steel contributes to the failure. Still another holds that oxygen must be present to produce the results noted. Then fatigue failures under certain conditions closely resemble embrittlement failures. There may be still other factors and influences.

A great deal of careful research has already been expended on this subject, and many valuable data have been developed. In spite of all this work the true nature of this form of failure is not positively known.

A study of the available data indicates that all such failures are intercrystalline in character. It therefore seems evident that the nature and causes of intercrystalline fracture in metals should be investigated as a primary step in the study of embrittlement failures. In other words, more must be learned of the nature and composition of the material at the crystal boundaries of metals and of the substance that binds crystals together. With such data available, the contributions of the factors such as stress, caustic soda, other chemicals, temperature and fatigue, in accelerating the rupture of the crystal bond, can then be more readily determined. Early research on the nature of intercrystalline fracture therefore seems imperative.

A Circulating Library for Engineers

RURAL districts have taken to reading with avidity since the institution of the automobile circulating library. The motive behind Oil Engine Week in April was somewhat similar to this library plan, and the results are far reaching.

At the annual meeting of the several engineering societies noteworthy papers are read, and the discussion that follows is usually of great practical value. Unfortunately, most members of these societies are unable to attend these meetings, as the time and expense involved are considerable. Oil Engine Week is the answer to the problem confronting those who are interested in oil-engine development but live at too great a distance to attend annual meetings. Inaugurated three years ago, the meetings have shown a constant improvement in the quality of the papers presented. A number presented at the meetings held three weeks ago were equal in caliber to any offered at annual meetings of the engineering societies, and the attendance at the hundred meetings held was probably twice the total membership of any of the national societies participating in the movement.

Would it not be of advantage if the national engineering societies would adopt this idea for other subjects than oil engines? By having able speakers at meetings scattered from California to Maine, engineers would begin to feel that membership in an organization brought other advantages than the display of a button. If service is the modern slogan, something should be done to give the Alaskan member a return for his annual dues.

Ratings for Water-Power Developments

A COMMON language in the power industry has become a prime necessity, if much of the present confusion and misunderstanding is to be eliminated. Many of the old methods of rating long since failed to meet the needs of the industry. The term boiler horsepower no longer conveys any idea of a boiler's capacity to produce steam, and it is falling into disuse. There are also other classes of equipment in which the word horsepower might well be abandoned.

When waterwheels were first used for industrial power, they were connected to the driven machine by mechanical means. Only one power rating was involved, and in this the horsepower served a useful purpose, just as it did in the steam engine used under similar conditions. With the present systems of power generation and transmission, waterwheels are generally connected to alternating-current generators, which are rated in kilowatts, or kilovolt-amperes, at a certain power factor. Another feature that enters into this problem, is the power rating of rivers on which the plants are built or are to be constructed. At the present, the rating of rivers is a rather indefinite quantity. As long as water power was used in local industries, the rating of rivers was of little importance except to those utilizing the power. Their chief interest was that there might be a fair assurance of water to produce a certain amount of power at a particular site. If there came a dry season and the water failed, it was accepted as an act of Providence, about which nothing could be done except to wait until nature provided the needed water. These developments for the most part were comparatively small, and of local interest only.

Electrical transmission of power over long distances has changed all this. It is no longer necessary for industry to go to a water-power site—the water power can be brought to industry. This has changed the interest in water power from one that is local to one that may involve several states or the whole nation. All this makes a common unit of rating water powers of great importance.

As things now stand, the rating, such as it is, is

generally horsepower up to the waterwheel coupling, and then it changes to kilowatts or kilovolt-amperes, with or without a power-factor reference. Unless the power factor is included in the generator rating, no definite conclusions can be arrived at, as to the output of the generator, and of every machine it should be known how much power it is capable of supplying.

The recent recommendation by the committee on river ratings, under the official leadership of the United States Geological Survey, that the power of rivers should be rated in kilowatts has much to commend it to everyone interested in the power industry. When we start with kilowatts in the water of our rivers, convert these into kilowatts at the coupling of the waterwheel and supply kilowatts at the generator terminals, which are delivered as kilowatts over the transmission and distribution lines, a real advance will have been made toward a common understanding of water-power developments. Add to this a specific statement defining how long during the year the power is available, such as the committee has suggested, and another source of confusion will be eliminated.

The Internal-Combustion Boiler

THE idea of an internal-combustion boiler is being discussed anew, and there is a small unit working in Germany. It is, in effect, a simple shell boiler, operating at one hundred and twenty pounds per square inch gage, with an oil flame burning in a bubble within the mass of water, air for combustion being supplied by a compressor at a pressure two or three pounds above that within the boiler. Although it is difficult to maintain a flame below the water line, there is nothing impossible about it. The oxyacetylene cutting torch has been used under water by divers for cutting submerged steel.

An internal-combustion boiler was built and operated, in conjunction with an engine, some twenty years ago in this country. Professor Sidney A. Reeve, of Worcester Polytechnic Institute, was active in this experimental development and reported excellent operating results, but remarked that the probable cost of the equipment would not justify its commercial exploitation. But that was twenty years ago. Today fuel costs more and the demand for higher efficiency is more urgent. Perhaps the present laboratory apparatus will issue in practical working equipment.

A boiler of this type delivers a mixture of flue gas and superheated steam, which can be used in an engine. So far as the gas is concerned, the action is similar to that of a compressed-air engine receiving air from a preheater. The heat added to the air in the preheater is converted into useful work at high efficiency. So far as the steam is concerned, there is nothing unusual in the use of steam superheated eighty to one hundred degrees Fahrenheit in an engine. Accordingly, the mixture should present no special problems for the engine designer. The exact characteristics of the expansion will probably not be markedly different from what is already well known.

An engine using a mixture of this sort obviously cannot operate condensing, since its working fluid is about half gas, which cannot be condensed. Nor can it be used for heating in apparatus in which it comes into direct contact with the material being heated, unless contamination by the flue-gas constituents would be unobjectionable. Moreover, in the work reported by Professor Reeve, the engine exhaust was at a temperature well below two hundred and twelve degrees, although, he said, it looked and sounded exactly like the exhaust from an ordinary steam engine. In spite of these restrictions the process presents possibilities for improved efficiency under proper circumstances.

The boiler is a compact unit, and the external equipment for maintaining the flame under water seems to be fairly simple. Since the products of combustion pass to the engine, there is no chimney in the ordinary sense. The engine exhaust pipe carries off everything.

The efficiency of the boiler is high. Radiation is reduced with the elimination of the furnace. There is no flue-gas loss. An odd thing about the present unit in Germany is the indication that the heat accounted for in the gas-steam mixture leaving the boiler exceeds the heating value of the fuel burned. Time will doubtless clear up this difficulty, either by discovering errors or developing an explanation. Combustion under such radically different conditions may entail new consequences.

Whatever the outcome, here is another new development in these days of many new things. The engineer who refuses to keep his mind open and who acts as if he thought he knew all he ever would need to know, is in danger of being left behind in the race for cheaper power.

Use the Tachometer in Starting a Steam Turbine

IN BRINGING a steam turbine up from a cold stand, it is good practice to warm it up slowly or else, in the case of a smaller machine, to bring it up to speed as rapidly as possible. The reason is that either of these methods will avoid excessively non-uniform temperature distribution through the metal of the machine. If one side of the rotor is hotter than the other, it will, through expansion, stick out slightly farther from the center, and this will unbalance the high-speed turbine and cause it to run "rough," perhaps to a serious degree.

The best practice in warming up large turbines seems to be to increase their speed at a constant rate, such as one hundred revolutions per minute every five minutes. This cannot be done by guessing. A tachometer must be used—either a hand instrument applied intermittently to the end of the shaft, or a permanently installed device with a clutch connecting it to the turbine or governor shaft.

The operator of small turbines will do well to copy this practice if he is troubled by rough starting of his machines. By trial he can develop a schedule that proves good for each machine, and if he has kept records of his experimental trials, he can duplicate the best procedure every time he has to start that machine.

Now and then one finds an engineer who keeps no records and does things by "feel," and seems to get away with it, but for most men a definite schedule, checked by appropriate instruments, is the only safe and sure way to secure good results day after day. It may seem foolish to use a tachometer frequently while starting a turbine, but it may open the way to avoiding unpleasant and perhaps injurious vibration.

The steam turbine will not stand excessive vibration indefinitely, and the engineer should do everything in his power to prevent it:

Ideas From Practical Men

Readers are urged to use this department for the exchange of practical operating information. A minimum of five dollars will be paid for contributions accepted

Removing Friction Gage-glass Rings

Not infrequently, a brass friction gage-glass ring becomes stuck so tightly on the cast-iron body of the gage that it is practically impossible to get it off without serious damage to the ring. The rings on most gages are of light brass and not made for rough treatment.

The illustration shows how an old piece of rubber-covered extension cord can be used to get a ring off without damage. This cord is about $\frac{7}{16}$ in. in diameter and can be laid back of the ring as shown. Then, if the cord is struck with a hammer the ring will not be

Extension cord prevents damage to the gage-glass ring when removing it from the gage body

marred or dented in the least. With this method almost any stuck ring can be readily removed from the body of a gage without bending or denting it.

Missouri, Iowa. F. W. BENTLEY, JR.

Pointers on the Operation and Maintenance of Artesian Wells

Some water-works plants and industrial plants derive their water supply from artesian wells. Once these wells have been driven and working, they give little trouble. Frequent testing and observation will tend to keep them in good condition.

In operation, the wells become clogged, owing to infiltration of sand and dirt through the strainers. The outsides of the strainers become clogged and the well is believed to have gone dry. This is true, but the well only is dry, the source of supply is probably ample as ever but cannot get into the well because of the clogged strainer.

When more water than the well is designed for is drawn, the well is overloaded. The water can not seep through the surrounding sand or earth fast enough to supply the demand. This condition causes the sand around the well to be carried through the strainer, gradually forming a hollow space around the strainer and the bottom of the well. When this space becomes large enough, the casing of the well drops down. The top of the casing is then open and dirt and surface water will soon fill the inside of the well. If this condition is noticed in time it can easily be remedied by cementing the top of the well casing, before the well becomes full of dirt.

Checking up on the depth of the well at frequent intervals will indicate any tendency to fill. For instance, if the bottom of a well is reached at 100 ft. and a short time later shows only 95 ft., it indicates that either the casing has dropped or the strainer has broken. If the strainer has broken, it will be necessary to pull the whole casing out. If the casing has dropped, digging around the top of the well will show where the trouble is. No harm can come of this, and the remedy is to cement the space around the top of the well and the drop suction.

Washing the wells out when the water supply from them becomes inadequate, is resorted to in order to restore normal supply. This is accomplished by the use of compressed air. A simple way is to take off the plug in the tee on the top of the well and put a nipple and tee in its place. In the top of this tee place a plug with a hole big enough to allow a $\frac{3}{4}$-in. pipe to slide through it. The depth of the well should be taken with a tape measure and enough $\frac{3}{4}$-in. pipe screwed together to reach within a foot of the bottom of the well. A clamp on the pipe, resting on the plug, will hold it in place. With wells of 100-ft. deep or so a three-legged derrick is a handy rig for lowering the $\frac{3}{4}$-in. pipe.

The top of this pipe should have a valve to control the air and a flexible connection such as a rubber hose should be used to connect it with the air supply. With this combination the pipe can be lowered and raised easily. After turning the air on, the water will flow out the side of the tee and if necessary a piece of pipe can be screwed into the tee to carry off the water. Shutting off the air supply for a few moments every 15 minutes or so will agitate the water at the bottom of the well, so that any dirt will be more readily carried out.

Mention might also be made of the pottery well, in which a casing of tile pipe is used. The strainer part of this type of well is made of tile pipe with oblong perforations through which the water filters. Pottery casings are used only on comparatively shallow wells of 50 ft. or less.

The places from which water can be obtained and the depths are varied. In some localities, Long Island, for instance, a well can be driven through salt water to a depth of only 50 ft. and pure drinking water can be obtained. A little farther on one might have to go down 100 ft. to get good pure water. I have seen wells driven to a depth of 350 ft. and give a good flow of water from a 10-in. pipe, while 500 ft. away no water could be obtained at this level. JOSEPH O'BRIEN.

Rosedale, L. I.

Repaired the Fault Without Finding the Trouble

It is not uncommon that the cause of trouble is eliminated without the fault being located. A case in mind is that of a 15-hp. squirrel-cage induction motor that had been acting in an erratic manner during starting. Sometimes it would develop sufficient torque to start its load and at other times it would stall. After several things had been tried to remedy the trouble, it was discovered that the rotor bars were grounded to the core. As there appeared to be nothing else that might cause the difficulty, it was decided to reinsulate the motor winding. This produced the desired effect, for the motor went into operation and gave no further trouble with low starting torque. Everybody was satisfied that the rotor insulation was the source of the trouble.

It has become general practice on modern induction motors to use uninsulated squirrel-cage windings. The bars are driven into the slots to make a tight fit with the core iron, and in many cases the end rings are cast or welded on, thus making a winding that is practically free from trouble. The successful operation of this type of construction contradicts the supposed cause of the trouble previously referred to, a grounded rotor winding. In this case the cause was poor connections between the end rings and the bars. When the winding was taken apart to reinsulate the bars, all the connections were cleaned and made up tight when the winding was assembled, which cured the fault without its being discovered.

Whenever trouble occurs with squirrel-cage motors developing low torque, one of the probable causes to consider is the rotor-winding connections, particularly if these connections are bolted, as was commonly done in the earlier types of machines. Other causes of this trouble are low voltage, high frequency, worn bearings and defects in the stator windings. C. O. MILLS.

Philadelphia, Pa.

Can a Feed-Water Regulator Save Coal?

Once I called on an engineer who told me there had been a man to see him who wanted him to install a feed-water regulator, and that he would guarantee a saving of 5 per cent in coal. He thought that was a foolish statement to make, and I said, "Well, let us analyze the situation and see." It was a one-man plant. He had an engine, one boiler and a closed feed-water heater. In addition to running the engine and boiler, he had various jobs to do up through the factory, and would sometimes be gone a half or three-quarters of an hour. He was a careful man, so before leaving the boiler room he would speed up his pump, fill the boiler to the top of the glass and shut down the pump. He knew then that he had plenty of water for three-quarters of an hour. When he returned to the boiler room, the water was low, so he started the pump and filled the boiler again.

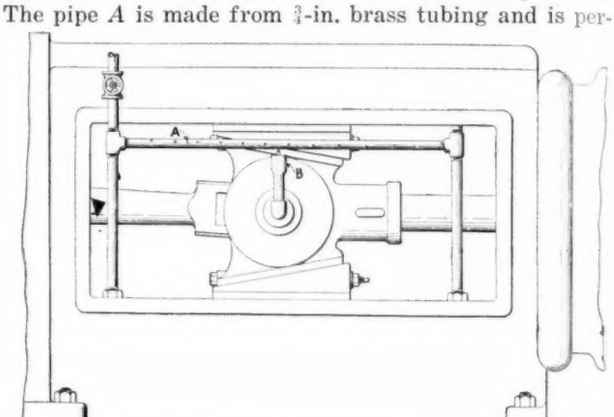
Now let us see what happened. When feeding the boiler at the rate at which the water was evaporated, he would get a feed-water temperature of 208 to 210 deg. F., but the way he operated the pump, the water passed through the heater so rapidly that it did not have time to absorb the heat in the exhaust and consequently he was putting the water into the boiler at about 100. For every 11 degrees the temperature of the feed water is raised by steam that would otherwise be thrown away, we save one per cent. And the difference between 100 and 210 is 110 degrees, or 10 per cent, that would be saved in this case by the use of a feed-water regulator, so this man would have no trouble in saving 5 per cent. We never thought of it that way before.

Chicago, Ill. P. H. HOGAN.

Adequate Lubrication Lessens Maintenance Charges

One of the secrets of continuous operation and few repairs is, according to Alexander Dowbrowski, chief engineer of the power house, Balboa Shops, down in the Canal Zone, plenty of lubrication. It has been his experience that few engines of air compressors have sufficient provision for lubricating the various bearings, particularly the crosshead pin and slides. To overcome this difficulty he has devised the method shown herewith for lubricating the crosshead pin.

The main features of this device are the horizontal pipe *A* near the upper guides and the wiper and receiving cup which conducts the oil to the crosshead pin at *B*. The pipe *A* is made from ¾-in. brass tubing and is perforated with a series of small holes as shown. It will be noticed that these holes are not in a horizontal plane, but begin near the top of the pipe at the left and are fairly near the bottom at the right. This pipe is leveled parallel to the guides by means of adjusting nuts at the lower end of each support.



Device for continuously oiling crosshead of air compressor

The oil comes in from the left, and the object of the peculiar arrangement of holes is to secure an even distribution of lubricant along the outside of the pipe. Since the oil pressure is higher near the point where the oil comes into the pipe, the outlet hole is higher and this arrangement of holes gives a practically uniform distribution of oil. The oil flows through these holes and runs down to the underside of the pipe, where it is wiped off by a tongue or central partition in the cup *B*. This wiper does not touch the pipe, but runs close to it, so as to wipe off as much oil as possible without actually touching it. This method secures a practically uniform flow to the crosshead pin during the whole length of the stroke and has proved satisfactory over an extended period. The amount of oil flowing into the pipe can be regulated by a valve between the pipe and the oil supply. H. C. FRANCIS.

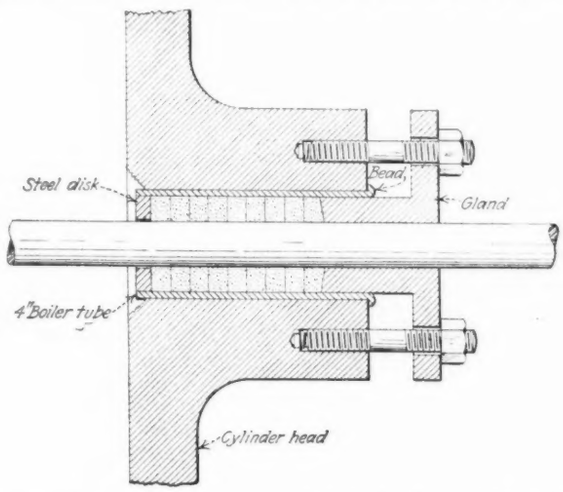
New York City.

Comments from Readers

How Packing Was Held in Stuffing Box After Bottom Was Broken Out

While reading C. H. Paeplow's method of repairing a broken stuffing box in the April 5 issue, I recalled a similar experience with a Corliss engine in which the repair was made in a little different manner.

The bottom of the stuffing box gave way as shown



Boiler-tube sleeve was expanded in broken stuffing box

in the illustration, and not wishing to incur the expense and time of disconnecting the cylinder from the frame and putting in a new head, I repaired the old head as shown. The inside of the stuffing box measured just 4 in., so a sleeve was made from a piece of 4-in. boiler tube with a disk welded in one end to form the bottom of the box, and this was expanded into the stuffing box with the boiler tube expander, then beaded on the outer end as shown. The gland was turned down to fit inside of the sleeve, and packing having a smaller outside diameter was used in place of the regular packing. This made a quick and permanent repair, which was never changed. H. R. ROCKWELL.

St. Louis, Mo.

The Use of High-Pressure Steam in Marine Power Plants

The excerpts from the talk delivered before the Propeller Club by Prof. H. L. Seward, in the March 8 issue, will be of interest and value to marine engineers.

Professor Seward alludes briefly to economizers and air heaters. The writer has urged more than once, in articles and letters in the technical press, that the possibilities of the light and compact steel-tube economizer should be considered afresh by marine engineers. It is true that the steel-tube economizers of the Belleville boilers used in the British Navy many years ago were not a success and corroded rapidly. But today economizers with protected tube surfaces are available, and the danger from external corrosion is practically eliminated.

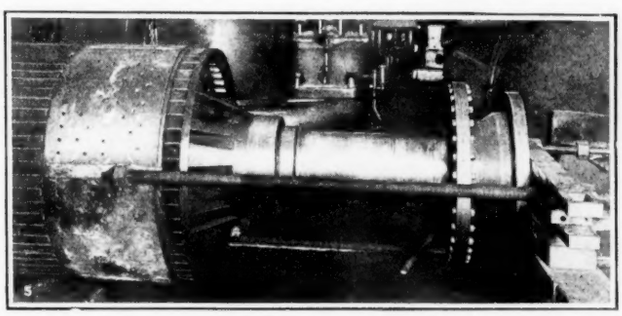
The mechanism of corrosion is now more fully understood, and with the growing use of closed feed systems on board ship the likelihood of internal corrosion is much less. With bleeder heating of the feed the scope for the economizer is somewhat reduced, but it may be shown that for good over-all efficiency and simplicity the combination of economizer and bleeder heating of the feed is an attractive proposition. The possibility of heating the combustion air by bled steam might be considered. This practice is now beyond the experimental stage, although it has not met with any approval in this country. In marine work especially, it would appear to be the solution of the air-heating problem.

The question of maneuvering with ships equipped with bled-steam-driven auxiliaries is not a serious one, although, as Professor Seward said, it is necessary to fit an automatic governor to supply live steam to the auxiliary main when the turbine is maneuvering or on light load. A year or so ago the writer suggested a similar arrangement to that already employed on process steam "pass-out" turbines, and this would seem to be a simpler method of working than that of arranging for an automatic shift-over to electrical auxiliaries. In any case it seems certain that the high-pressure plant has come to stay and the successful solution of these questions must come in the near future.

Northwich, Cheshire, England. B. M. THORNTON.

Removing Retaining Rings from Generator Rotors

In the Feb. 15 issue there appeared an illustrated article describing the method used in removing the retaining rings from a field of a turbine-driven generator



Pulling-off bolt welded to generator field retaining rings

as manufactured by the General Electric Co. This consisted of welding pulling-off bolts to the rings.

The generator manufacturer does not consider this good practice and recommends against the use of such a method for the following reasons: These parts are made of alloy steel necessarily heat-treated in order to obtain the required physical properties. Heating sufficient to weld strips to these rings may result in

changing the physical structure to a point resulting in serious consequences.

In order to remove these rings from the revolving field of turbine generators, it is only necessary to: First, take out the grub screws anchoring these rings to the centering ring and the latter to the shaft; second, plug all ventilating holes with asbestos to prevent the flame injuring the insulation beneath the end rings; third, heat the rings uniformly to a moderate temperature, using either gas burners or torches over their entire surface, when the rings may be easily removed.

J. C. MAHONEY,
Supt. of Turbine Installations,
Schenectady, N. Y. General Electric Co.

Flattening Copper Pipe To Make Electrical Connections

I was interested in the article in the March 29 issue on "Flattening Copper Pipe for Electrical Connections." We have employed this method successfully for several years, using a hydraulic press which is normally used for making joints on the aluminum steel reinforced cables.

We made a top and bottom die, and one application presses the copper tubing to a correct terminal lug without kinking or disfiguring the pipe in any way. We have handled pipe up to 2-in. iron pipe size successfully with considerable saving.

E. V. CATON,
Winnipeg, Man. Manager Electric Utility,
Winnipeg Electric Company.

Faulty Operation Causes Explosion and Damage to Boiler Setting

In the March 22 issue is an account of a gas explosion in the setting of a 2,500-sq.ft. inclined-tube boiler. The fact that the damage was confined to the roof and the upper parts of the walls seemed to leave the impression that the explosion centered in the space between the center and rear upper drums. A moment's reflection will convince one that the force of the explosion must be relieved at the least resistant parts of the setting, which are the roof and the upper parts of the walls. The lower parts of the walls are strengthened against lateral forces by the burden of the brickwork above. I have examined the effects of several such explosions, and in every case the damage was practically confined to the roof and the upper parts of the walls; and in each case the consensus of opinion was that the force of the explosion was centered in some "gas-pocket."

There is a notion, popular among boiler operators, that any region in a boiler setting that is not directly swept by the gases of combustion is a "pocket," and as such is a menace. A consideration of the diffusive property of gases should convince one that the contents of "gas-pockets" should change in a short time, not mentioning the infiltration through baffles and walls which are always sufficiently pervious to permit ventilation under the action of the draft. Furthermore, the pressure exerted by the explosion of the comparatively small volume of gas contained in one of these "gas-pockets" would not be sufficient to wreck the setting of a boiler with an open damper, even if the temperature at that point were high enough for ignition, which is unlikely. One can be assured that an explosion sufficient to damage the brickwork seriously was caused by a setting full of an explosive mixture.

The factors necessary to the combustion of a gas are a mixture of the gas and air in certain proportions to which is applied the equivalent of an open flame. If any of these three are absent, there is no combustion, or explosion. According to the account of Mr. McHugh the supply of gas had not been interrupted. There must have been ample draft because the boiler had been fired for more than twenty minutes during which time the pressure had risen from 50 to more than 70 lb. It does not seem possible to increase the boiler pressure to that extent without a good draft being established. The explosion demonstrated that the means of ignition was present in the hot brickwork. With sufficient gas and air, and the means of ignition, what then caused the explosion?

A slug of air is a plausible explanation if the source of the air is not at too great a distance. Should the air-gas mixture be just within the limits of combustibility upon reaching the boiler, it would be still further diluted with the air entering the burner opening, so combustion could not be maintained, and the fire would be extinguished. Should this be the explanation then other gas-users in the vicinity would have experienced the same trouble from extinguished fires, and could so report. Also, the gas company could (if it would) report whether there had been any work on its pipe-lines that may have contributed to the introduction of air in considerable quantity.

It seems that something besides faulty installation caused the explosion. If there were something inherently wrong with the installation, then explosions would be the rule and not the exception. There are a number of causes that can be imagined, among which are deliberate tampering with the equipment. Should a gas- or oil-fired furnace have its damper closed without the fuel supply being diminished, an explosion may result.

In the days of cheap natural gas in the Middle West, many plant operators constructed burners from pipe-fittings. Some of these made not the slightest pretense of obtaining a mixture of the gas and air—were mere jets of large size. With a fluctuating pressure, existing where no definite means of pressure regulation was employed, these jets behaved badly. Occasionally, with a rise of pressure, the velocity of the entering gas would exceed the velocity of flame propagation and the fire would go out. Checkerwork targets of firebrick were employed to re-ignite the gas, which prevented damaging explosions. Several burners always gave better results than one—there was a better chance of getting the intimate mixture of gas and air so necessary to good combustion.

Following accidents like the one under discussion, where the cause is obscure, it is well to consider all things that might contribute to such a mishap. Then by eliminating the improbable ones the investigation narrows to the probable causes from which one might be able to select the actual cause. Mr. McHugh found that the pressure in the gas system had not changed, which eliminates this as a probable cause. That there had been an interruption of the air supply by reason of insufficient draft may be eliminated as a probable cause, as this fault would have manifested itself in less than twenty minutes. Whether there had been a malicious or mischievous tampering with the damper may not have been considered when searching for the cause of the explosion, but it may be set down as a probable cause, more or less remote, depending on the amount of "horse-play" permitted in the plant. Trapping water

and oil out of gas lines is generally practiced, and was in this case, so this may be eliminated as a probable cause. Whether the gas main contained an air-gas mixture incapable of maintaining combustion is uncertain, but may be set down as a probable cause.

For obvious reasons, it would be hard to determine whether the last was the cause of the explosion. Unless other gas users in the vicinity experienced the same trouble, fastening the blame on a defective supply would meet with some difficulties, as it is unlikely that the gas company would voluntarily assume guilt.

In view of the dangers attending the use of gas as a boiler fuel, it would seem that the user would avail himself of the protection afforded by a target wall or its equivalent in a pile of firebrick. In the absence of a target wall the resumption of the flow of gas after an interruption would fill the setting before ignition could occur, and a damaging explosion might follow. The target wall, set a few feet from the burners, would ignite the gas before a large volume could enter.

Los Angeles, Calif. C. O. SANDSTROM.

Rational Measures of Boiler-Plant Investment and Capacity

For many years engineers have told one another that the custom of rating boiler units on an arbitrary basis, usually ten square feet of boiler heating surface per horsepower, is illogical. However, as long as this convention conveyed a fairly definite impression, the average engineer refused to become excited over academic distinctions and sentiment in favor of more rational expression made no more real headway than the perennial agitation favoring substitution of the metric system for the familiar English units in engineering work.

Recently and particularly during the last two years, the developments in steam-generating units have been such that the familiar convention of rating is rapidly going into the discard as meaningless.

Merely as a measure of normal boiler-heating surface, the rating in terms of boiler horsepower may be harmless, but the danger lies in the tendency to continue thinking in terms of other units based on this convention. For example, the following units have been in use and still persist: Boiler-plant investment per rated horsepower; cubic feet of boiler house per rated horsepower; developed capacity of boiler units in per cent of rating; furnace volume per rated horsepower.

The question naturally arises as to why the convention of rating, used for so many years, now becomes not only meaningless, but misleading. This does not mean that the use of the boiler horsepower of 33,479 B.t.u. per hour as a measure of developed capacity is undesirable. On the contrary, it is more precise than expression alone in pounds of steam per hour. It is the reference to arbitrary rating, which is undesirable. A brief review of the present tendencies in boiler-plant design and the underlying causes should answer this question and also indicate correct lines of thinking.

Before the intensive developments of the last few years boiler units for stoker firing were more or less standardized. For horizontal water-tube boilers, fourteen 4-in. tubes high or the equivalent was considered good practice. Developed capacities of 250 to 300 per cent of rating represented the maximum in power-station practice. Feed-water economizers came into favor as a means of economy, particularly as the use of motor-driven auxiliaries increased, but it is fair to say that until recent years development in the economical generation of steam hardly kept pace with its utilization.

The desire for high capacities and efficiencies, coupled with low investment cost, furnished the underlying motive for rapid developments in steam generation. The principal factors which shaped these developments are: (1) Availability of larger units; (2) developments of improved methods of firing; (3) development of air preheaters; (4) increased use of steam bled from prime movers for heating feed water; (5) development of radiant-heat absorbing surfaces; (6) higher pressures; large unit savings in investment and in efficiency.

Improved methods of firing, coupled with application of radiant-heat absorbing surfaces, enable and permits greater intensity of heat liberation in the furnace.

The air preheater provides a method of reducing the temperature of exit gases from the boiler and superheater, thus economizing heat and either replacing or supplementing the economizer. Also, preheated air improves the rapidity and completeness of combustion and results in higher furnace temperatures, thus increasing the effectiveness of radiant-heat absorbing mit greater intensity of heat liberation in the furnace. crease the efficiency by reducing the carbon in refuse.

Bleed steam for feed heating can be utilized to the extent of replacing the economizer wholly or in part.

Thus a large variety of combinations has been placed at the disposal of the designer so that he is now able to choose one that he believes best solves a particular problem. Under such conditions complete standardization is out of the question and, indeed, is not desirable.

On the one hand, there are many horizontal water-tube boilers with twenty 4-in. tubes high, and some twenty-four 4-in. tubes high absorbing heat entirely or almost entirely through convection. At the other extreme are units in which all the normal steaming surface is of the radiant-heat absorbing type. At present there is a reaction in favor of convection surface.

Comparison of the extremes shown for present-day practice yields interesting results. Assume two steam-generating units with horizontal water-tube boilers of the same width and length of tubes, one being six 4-in. tubes high and the other twenty-four 4-in. tubes high. The boilers may have identical furnaces, and we may assume the same furnace conditions and heat release. Now assume that the developed capacity of the steam-generating unit with the twenty-four high boiler is 350 per cent of the arbitrary horsepower rating; then the developed capacity of the steam-generating unit with the six high boiler is approximately 1,400 per cent of the arbitrary horsepower rating. The foregoing assumes the same actual outputs and equal efficiencies for both units, obtained by suitable feed-water economizer or air-preheater surface, or both.

As illustrating the trend that renders normal boiler surface almost a minor factor in some recent developments, *Power* recently published an account of a steam generator in which the normal boiler surface is less than one-third the total water surface, including water walls and feed-water economizer, and in which the air-heater surface was more than seven times the normal boiler surface. This unit developed a capacity of over 1,700 per cent at the arbitrary rating of ten square feet per horsepower on the normal boiler surface.

New York City. E. L. CLIFFORD,
McClellan & Junkersfeld, Inc.

New and Improved Equipment

Stratton Furnace Burns Crushed Coal in Suspension

The illustrations show a cross-section and other views of a furnace recently developed by the Stratton Furnace Co., Chicago, Ill., to burn crushed coal (in sizes up to ¾ in.) in suspension.

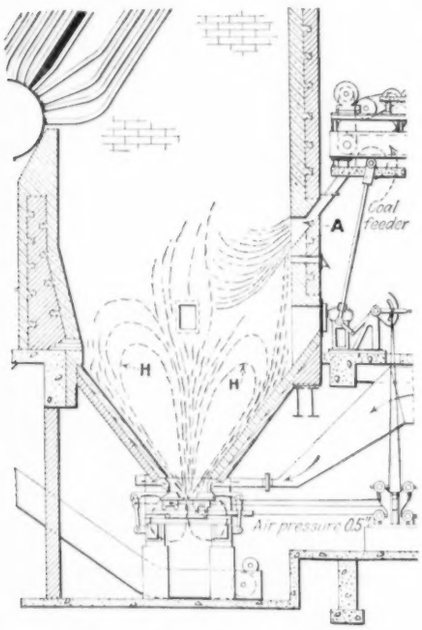


Fig. 1—Cross-section of typical furnace arrangement

The principle involved is that of supplying coal to a furnace in small sizes and supplying the air for combustion through an opening in the bottom of the furnace at a sufficient velocity to carry the particles of coal from the grate upward into the combustion zone, where they are burned off in suspension.

The furnace consists essentially of a firebrick chamber similar in many respects to a pulverized-coal or stoker-fired setting; a feeder for supplying the crushed coal to the furnace; reciprocating grate bars for moving the coal that falls to the grate into the air stream, and a mechanism for operating the bars and varying the air opening through the grate to any desired width.

Referring to Fig. 1, which shows a typical furnace arrangement, the crushed coal is fed to the furnace through the nozzle *A* together with about 25 per cent of the air required for combustion. Upon entering the furnace the larger particles of coal drop to the inclined bottom of the furnace and roll to the grate bars *B* and *C* (see Fig. 4), while the finer particles are burned in suspension as they leave the nozzle *A*.

Owing to the reciprocating movements of the grate bars *B* and *C* the larger particles of coke and ignited coal, together with the clinker and slag, are pushed to the opening *F* between the grate blocks *D* and *E*, where they are met by a blast of preheated air from the ashpit. The coke and ignited coal, being specifically lighter than the clinker and slag, are blown upward and burned in suspension, while the heavier refuse drops into the ashpit below.

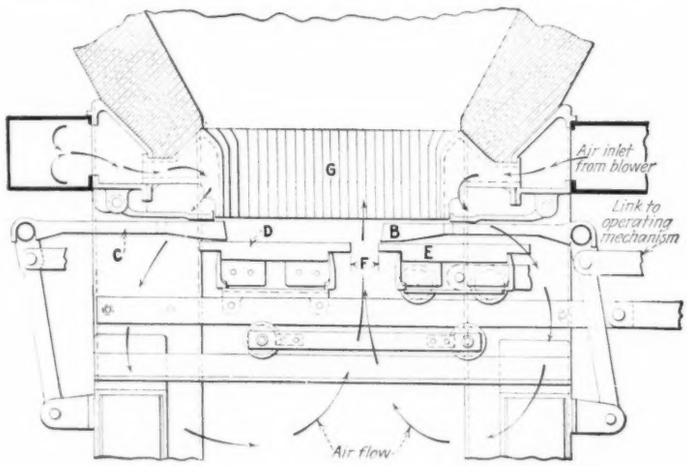


Fig. 4—Cross-section of furnace throat showing grate mechanism and air travel

In the furnace the larger particles, which are blown up by the air blast, tend to take the path indicated by the lines *H* and fall again to the bottom, from which they are once more carried upward. This action continues until the particles are entirely consumed.

Referring to Figs. 2, 3 and 4, which

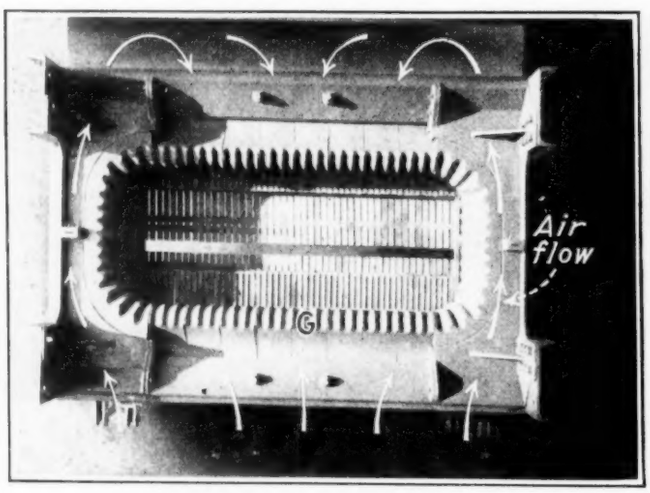


Fig. 2—Top view of furnace throat

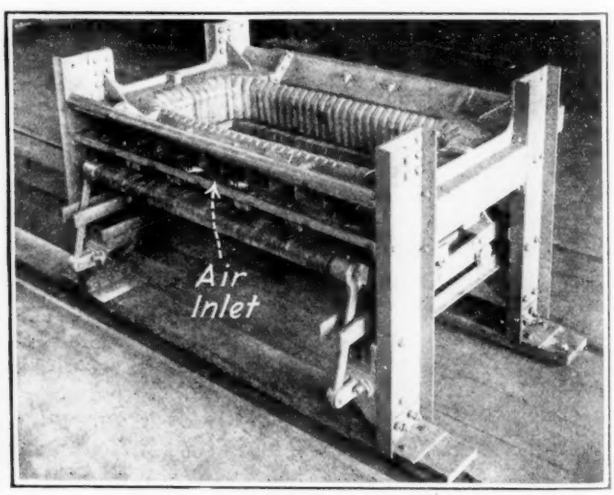


Fig. 3—View of throat and slicing grate mechanism

show the assembly and cross-sectional views of the furnace throat and slicing grates, the details and operation of this mechanism will be more clearly understood. The throat (see section Fig. 4) consists of a series of air-cooled corrugated cast-iron blocks, *G*, and directly below are the slicing grates *B* and *C*, which move forward and backward continuously (about three times a minute) during operation in opposite directions to the grates *D* and *E* mounted on rollers immediately underneath the slicing grate.

The control mechanism, which serves to operate the slicing grate and the grate bars, consists of a number of levers and radial sectors with intervening bell cranks, the control levers and sectors being placed on the operating floor (see Fig. 1) in front of the furnace. The sectors are made to oscillate continuously during operation at a speed of 3 strokes per minute.

Provision is made in the operating mechanism for varying the width of the opening *F* to suit the varying grades of coal and the various ratings on the boiler; it also permits moving the opening a certain amount in relation to the center line of the furnace and changing the stroke of the slicing grates accordingly.

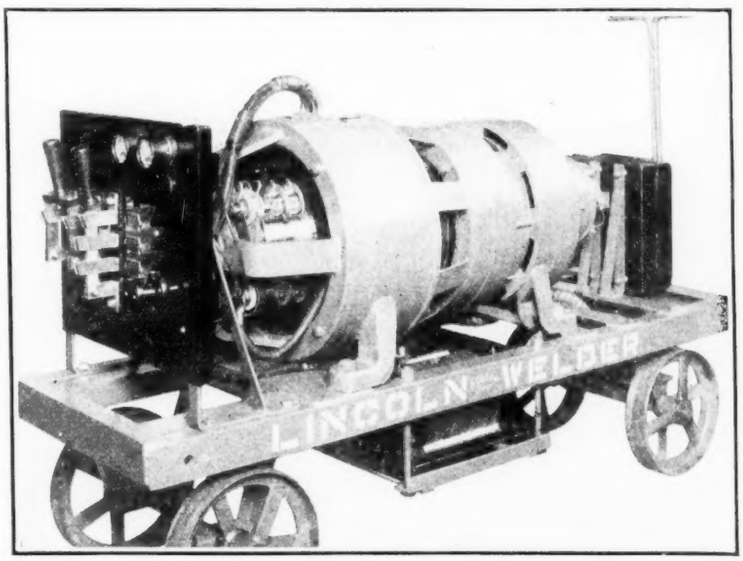
The forced-draft air which enters the furnace through the slot *F* and the air spaces in the grate bars *D* and *E*, is first passed through the chamber surrounding the throat blocks, as indicated by the arrows Figs. 2 and 4. In passing around these blocks and through the ashpit, the air not only serves to cool the blocks and other parts of the grate, but it is preheated to a fairly high temperature before entering the furnace.

Although the velocity of the air through the opening *G* must be sufficient to carry the particles of coal well up into the furnace and give the desired turbulence, the static pressure required in the air chamber below the grate varies from 0.2 in. to 0.5 in. of water, depending upon the volume of air required to meet the load demands on the boiler. A slight suction is maintained on the furnace proper. The furnace is installed with either a central coal-crusher equipment or with a unit coal crusher in front of each boiler.

It is reported by the manufacturer that two furnaces of this type have been in operation for more than a year, one at the plant of the United States Gypsum Co., Oakfield, N. Y., and the other at Poehlman Bros., Chicago. These furnaces have been burning low-grade coal, and ratings as high as 250 per cent of normal have been obtained. It is also claimed that they operate smokelessly and around 14 per cent CO_2 can be maintained under practically all load conditions.

Lincoln Arc Welding Machines Made of Welded Steel

In the new arc welding machine recently introduced by the Lincoln Electric Co., Cleveland, Ohio, and illustrated herewith, the use of cast iron in the frame and other parts has, with the exception of two small parts, been entirely replaced by welded structural steel.



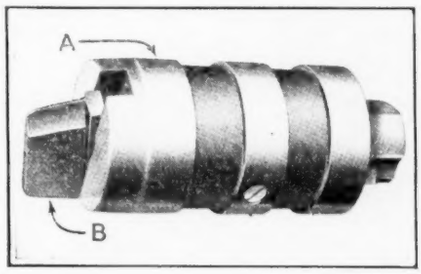
Welding unit of structural steel welded construction

The motor and generator end rings, brackets and connecting ring are all made of structural steel rolled to the proper shape and welded. The feet of the motor generator are made of drop forgings. The truck wheels are made of T-sections rolled to shape, and the hub is a piece of steel tubing. The usual slate switch and instrument panel has been replaced by a panel of sheet steel welded to the supports.

The substitution of welded structural steel in place of cast iron was brought about by the severe conditions to which portable welding equipment is subjected. It is claimed that the steel construction, owing to the fact that it will bend rather than break, reduces the likelihood of failure for the reason that the bent parts may be straightened and the unit put into operation without waiting for replacement casting.

Improved Dean Boiler-Tube Cleaner

Among the improvements recently made to the Dean boiler-tube cleaner manufactured by the Wm. B. Pierce Co., Buffalo, N. Y., are the lengthening of the shell *A* to form a guard for the hammer or vibrator *B* and a material reduction in the total number of working parts.



Improved tube cleaner with extended shell

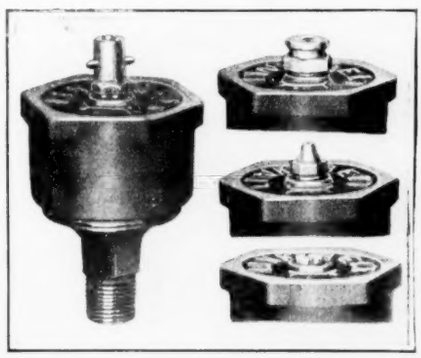
The lengthening of the shell, to form a guard of the vibrator, precludes the possibility of crowding the vibrator *B* onto the scale and thereby slowing down the work of the cleaner. A number of the working parts have been redesigned and combined into one piece, so that the total number of parts has been materially reduced.

These improvements it is claimed by the manufacturer, greatly simplify the operation of the cleaner and reduce the maintenance charges.

Link-Belt Grease Cup with Alemite Fittings

The Link Belt Co., Chicago, Ill., has recently introduced a line of malleable-iron grease cups fitted with Alemite and Zerk fittings in the cap, as shown in the illustration.

The use of these fittings facilitates the filling of the cups without removing the caps and without waste of grease, particularly where the cups are in inaccessible locations. The illustration shows the types of fittings with which the cups are being fitted; these include the standard Alemite, industrial- and flush-type Alemite and the standard Zerk.



Grease cups with Alemite and Zerk fittings

Low-Temperature Distillation*

Three Typical Processes of Low Temperature Distillation, the Calorific Value of the Semi-Coke Produced, and the Price at Which the Coke Should Sell—Conservative Estimate of Production Costs and Profit

By W. RUNGE†

THE purpose of this paper is to give a general idea of low-temperature distillation and show some of its potentialities and advantages.

Low-temperature distillation removes from bituminous coal those ingredients which are smoke-producing, and which, upon being removed as byproducts, have a greater value as such than as fuel. Many claims have been made of the vast amount of revenue that it is possible to obtain by distilling coal at low temperatures. It is true that a substantial and desirable profit is not only possible but also probable. Very little work has been done with the compounds found in low-temperature tar, and few of the derivatives can be used for dyestuffs or pharmaceuticals. We must therefore limit ourselves to an average profit of $1 to $4 per ton.

Low-temperature distillation has for the last 15 or 20 years been subjected to serious and intensive investigation. The processes that have been investigated and described are too numerous to mention. No attempt will be made here to describe these processes minutely. Only in a brief way will the theory upon which some of them are founded be discussed.

Distillation in the Rotary Kiln

Probably one of the most common types of furnace that is used in low-temperature distillation is known as the rotary kiln. It is about 8 to 10 ft. in diameter, 80 or 90 ft. long, and slightly inclined off the horizontal and externally heated. It is customary to feed the coal into the upper end of the retort and discharge it at the lower end. This type has not been successful, for the reason that the temperatures that are required for the distillation of coal greatly weaken the steel shell.

The coal must be heated to a minimum of 900 deg. F. and it is quite probable that the steel shell reaches a temperature as high as 1,500 deg. At 1,200 deg. F. the tensile strength of mild steel has almost reached its minimum, and as a consequence the life of these retorts has not been great. In their operation they are limited to the type of coal that may be treated. Strongly coking coal during heat treatment becomes plastic and not only adheres to the shell of the retort, but also tends to cohere, whereby the various lumps of coal in semi-plastic state, as they come in contact with one another form larger lumps, which are distilled with great difficulty. Some investigators have improved upon this type of furnace by using two or three rotary furnaces in series. In this case the coal is first subjected to a moderate heat treatment, which prevents its adherence to the shell. After this moderate heat treatment it is then subjected in a second rotary kiln to a higher temperature, with the result that a solid fuel is delivered in the form of hard, dense lumps.

Distillation in the Concentric-Drum Type of Retort

A retort employed in a German process consists of an inner and an outer drum. It is externally heated and the entire weight of both drums and their contents is carried by the inner drum. This drum is maintained at a temperature between 400 and 500 deg. F., or the point where steel has its greatest strength. The coal is fed into the inner drum and discharges into the outer drum. In the inner drum the only heat that reaches the coal is that which passes through the heated coal in the outer drum. This tends to destroy some of the inner drum coal coking properties.

English retorts in their general operation resemble a high-temperature by-product coke plant. They are of low capacity, and difficulty has been experienced in discharging the retorts. The fuel produced by this process has a low density.

Distillation in the Horizontal Stationary Type of Retort

This retort is a horizontal stationary one, in which the coal is propelled through the retort by means of paddles. The product is very light and fluffy, unsatisfactory for fuel, and must either be briquetted or pulverized. The fuel from this process lends itself readily to briquetting, but in order to produce a smokeless fuel, which is one of the prime objects of low-temperature distillation, it is necessary to bake the briquets in order to remove the smoke-producing ingredients of the binder. From each ton of coal there is obtained 0.7 ton of briquetted smokeless fuel. It is therefore advantageous to resort to those processes which produce a smokeless fuel in a natural lumpy state, and which do not employ briqueting.

Another method is the carbonization of bituminous coal in dust form, which will be considered later.

The author would not have it understood that none of these processes has made progress, nor that they will not succeed. It appears that one or two have reached the point where the cost of operation is so far reduced that the value of the products is sufficient to cover all costs. He doubts very much whether any one process will be able to fulfill all requirements of both domestic and industrial fuel.

Those processes producing a solid lumpy fuel are almost entirely confined to the domestic trade, while those that produce a finely divided, porous form of semi-coke are limited to industrial plants using pulverized fuel.

It is impossible to discuss the revenue from a low-temperature distillation plant until the amount of byproducts obtainable is determined, the type of coal undergoing treatment and the cost of raw material. The cost of the raw material includes the price at the mines and the cost of transportation, so we must first select the site at which the plant is to be located. There are certain advantages in locating the carbonizing unit at the mines but a market for gas produced is not usually found at the mines. Personally, the author feels that the best location is at a point where all the products of the distillation may be readily disposed of.

The number of B.t.u. per pound of coke will average 700 to 1,000 less than that of the coal from which it is made. This is a general rule for high-volatile, low-oxygen coals. In dealing with high-oxygen coals, it is quite often found that the thermal values of the coal and the coke are about the same, or possibly that of the coke is slightly higher.

Solid Fuel Plant Should Be Near Large City

It is evident that a solid fuel plant should be located in close proximity to a large city. The fuel market is not only larger, but there is a demand for gas, which rarely exists in the smaller town. We find in or about the larger cities tar-refining plants, which should reduce the freight on this liquid product and permit it to be sold at a higher price.

One other product made by low-temperature carbonization is that which is commonly termed "motor spirits." This product can be produced in the pure form, and its demand will naturally vary with the population of the center it supplies.

The value of the coke depends entirely upon the physical condition in which it is produced. Low-temperature coke, if it is to be used for domestic purposes, must either be produced in a natural, lumpy state, or briquetted. It contains approximately 12 to 15 per

*Abstract of a paper presented at the Kansas City Meeting, Kansas City, Mo., April 4 to 6, 1927, of the American Society of Mechanical Engineers.

†International Combustion Engineering Corporation, Milwaukee, Wis.

cent of volatile matter, is easily ignited, withstands transportation, and is absolutely smokeless. If we assume that coal under treatment contains 7 per cent of ash, then the finished semi-coke that is produced will contain 10 per cent of ash.

Price at Which Low-Temperature Coke Should Sell

Carbocoal, as made by the International Coal Products Corporation at Clinchfield, Va., sold at prices net to the plant that varied between $6.50 and $7.50 per net ton. This fuel was subsequently marketed in Chicago at a retail price of $14. It was the pioneer fuel of its kind in the United States. The author is convinced that a good low-temperature coke in either briquet or lump form will sell at $10 or $11 per ton, f.o.b. plant.

Anthracite runs from $8.75 to $9, f.o.b. mine, and retails within 100 miles of the mine for $14. Locating carbonizing plants near large centers of population, delivery could be made to the consumer at $13, allowing $2 per ton for delivery charges, leaving a net at the plant of $11.

The gas from these processes, when made in an externally heated retort, runs to 750 B.t.u. per cu.ft. In other cases where the retorts are heated internally, the gas can be produced with a calorific value running as high as 600 B.t.u.

Gas containing 750 B.t.u. or over, could be blended with a blue water gas and used for domestic purposes or could be blended with a producer gas and used for industrial purposes. Regardless of the type of process, the B.t.u.'s produced in gaseous form amount to approximately three million per net ton of coal treated. If, therefore, a gas of, say, 800 B.t.u. per cu.ft. is being made, we may expect the total production to be in the neighborhood of 4,000 cu.ft.

The cost, under the holder, of 550-B.t.u. gas averages 30c. per 1,000 cu.ft. Uncarbureted water gas or blue gas costs 20c. per 1,000. One cubic foot of blue gas blended with one cubic foot of low-temperature gas is equivalent to two feet of 550-B.t.u. gas. On this basis the low-temperature gas is worth 40c. per 1,000 cu.ft.

Before contemplating the distillation of coal by means of low temperatures, serious thought must be given to the type of coal available. It is doubtful whether a coal containing less than 25 per cent of volatile matter should be treated, because the yield of tar would be relatively small, whereas with a coal containing 30 per cent or more of volatile matter, a very good yield of tar can be expected. Setting up the value of the tar, we find it to be worth only 5 to 6c. per gal. If the producer of the tar is also going to be the refiner, then the tar will cost nothing. A figure of two cents a gallon will probably cover all refinery operating costs. On distillation an average low-temperature tar would yield 60 per cent of oil and 40 per cent of pitch when distilled to a high-melting-point pitch.

Cost Estimates

The most logical use for pitch seems to be as fuel. It is actually being used as such, being produced with a melting point of 300 deg. F. This is pulverized and used as powdered fuel and brings a return of $5 a ton where coal sells for $4.50. In view of the fact that it is practically ashless and contains over 15,000 B.t.u. per lb., this credit is not large. Assuming a yield of 25 gal. of tar per ton of coal, we obtain 10 gal., or approximately 100 lb. of pitch, with a value of 25 cents.

Most of the oil from the distillation of the tar would be utilized as wood preservatives, as disinfectants, and as flotation oils. Creosote oil is now selling at 16 to 18c. per gal. in tank-car lots. Disinfectant oil and flotation oils bring 20 to 25c. An average price of 16c. per gal. may be considered as conservative. With a yield of 15 gal. of oil the revenue therefrom is $2.40. This plus 25c. credit for the pitch makes a total of $2.65, from which a deduction of 50c. for distillation charges leaves a net of $2.15, or better than 8c. a gallon for the tar.

The only remaining item for which a credit is taken is that of motor spirits. With the right type of coal crude motor spirits will run between 3 and 4 gal. per ton, and on refining will probably yield 2 to 3 gal. of a product ready for use in automobiles. Tank-car shipments of this finished product is 19c. per gal., so that a credit of at least 47½c. per ton should be taken.

In summarizing the credit side of the operation for a plant carbonizing at least 500 tons of coal a day, the values of the various products have been reduced in order to present a more conservative estimate. This, then, shows the following:

0.7 ton of semi-coke at $8	$5.60
4,000 cu.ft. of 800-B.t.u. gas at $0.40 per M ft.	1.60
25 gal. of tar at $0.05	1.25
2½ gal. motor spirits at $0.15	0.37
Total	$8.82

Deducting the previous costs of $4.50 for the coal, $1.50 for operating charges, and $1 for fixed charges, making a total of $7, leaves a net profit of $1.82 per ton of coal carbonized.

All of the foregoing relates to those processes making a domestic product and producing it without resorting to briquetting.

Progress in Laboratory Study of Slag Erosion*

About a year ago a laboratory study of slag erosion was instituted by the A.S.M.E. Special Research Committee on Boiler Furnace Refractories to be co-ordinated with the field investigation started several years ago. The progress of this work at the Columbus branch of the United States Bureau of Standards is reported by Samuel J. McDowell, who directed the investigations.

Up to the present time various tests devised for predetermining the effect of slag on refractories have been found defective, and results obtained with them do not always agree with findings in practice. The object of the laboratory work has been to investigate slagging, with a view to developing laboratory tests which will properly evaluate the resistance of refractories to a certain standard slag.

The reason why satisfactory tests have not been devised is that fundamental information has been lacking. The laboratory is making a study of the most important slag-refractory systems, including a microscopic determination of the crystalline materials present, and their relation to both slag and refractories, followed by an endeavor to duplicate these results in the laboratory.

With the co-operation of the field investigation, samples of brick were sent to the laboratory after their life in service had been studied. A microscopic examination of these samples revealed, first, the slag itself, presumably in the same condition as it was deposited from the gases in the boiler, consisting largely of iron in the form of magnetite or hematite, glass, a lime-soda feldspar, and some mullite. The slag, which is about ¼ in. thick, gradually blends into a glassy interface, which in reality contains much more crystalline material than it does glass. The thickness of this interface varies between ¼ and ⅜ in. and grades into the unaltered refractory. The other usual laboratory tests were made on the refractories, including load and spalling tests, porosity, specific gravity and deformation tests.

With these findings as a background, two types of laboratory furnace construction have been tried. The first was long and narrow, and the test bricks were placed in the side walls with the burner in one end. In the second type the walls are permanent, and the brick to be tested is installed in the arch. The furnaces are fired with gas, into which was introduced a synthetic Illinois coal ash and powdered Illinois coal. The flame impinged against the surface of the brick, and the powdered coal burned to produce local reduction, simulating conditions in a boiler. An examination of the refractories used in this furnace development showed a similarity between the results obtained and the slag action in service. It was also found that the temperature to which any coal-ash slag had been subjected could be approximately determined by a microscopic examination of the slag. When subjected to furnace temperatures higher than 2,700 deg. F., the refractory seemed to be affected more from the heat itself than from the slag.

Work is being continued on the development of the furnace, particular attention being paid to the development of methods for controlling the variable factors.

Later in the investigation when a furnace has been developed which will duplicate service conditions and the effect of the variables is known, and working in connection with the committee appointed by the Refractories Institute, the authors hope to be in a position to determine the effect of such things as process of manufacture, alumina-to-silica ratio, size of grain, temperature of firing, etc., of the refractory, and later plan to prove their laboratory findings with the installation of panels of brick in commercial boilers.

*Abstract from *Mechanical Engineering*, May, 1927.

Boiler Feed Water Abstracts

ON PAGE 568 of the April 12 issue appeared the "boiler feed water abstracts" contained in the third report issued by Subcommittee No. 9 (bibliography) of the "Joint Research Committee on Boiler Feed Water Studies." The work is carried on under the auspices of the American Society for Testing Materials, the American Water Works Association, the National Electric Light Association, the American Railway Engineering Association and the American Society of Mechanical Engineers, with Sheppard T. Powell as chairman of the Advisory and Editing Committee.

The following abstracts contained in the fourth report of Subcommittee No. 9, of which Prof. George Stetson is chairman, consist of items selected by the regular editorial staff of the *Engineering Index* and issued through the courtesy of the A.S.M.E. main research committee.

Boiler Feed Water

Foaming and Priming — Present Knowledge of Foaming and Priming of Boiler Water, with Suggestions for Research, C. W. Foulk. *Am. Water Wks. Assn. Journal*, Vol. 17, No. 2, Feb., 1927, pp. 160-73. Progress report of Subcommittee No. 3 on Zeolite softeners, internal treatment, priming and foaming, and electrolytic scale prevention.

Pretreatment—Pretreatment of Boiler Feed Water, C. R. Knowles. *Am. Water Wks. Assn. Journal*, Vol. 17, No. 2, Feb., 1927, pp. 151-59. Progress report of Subcommittee No. 2 on water softening by chemicals (external treatment); operation of continuous and intermittent lime-soda water-softening plants; economic value of lime-soda softening preliminary to Zeolite softeners and to evaporators.

Treatment — Experience and Progress in Treatment of Boiler Feed Water (Neuere Erfahrungen und Fortschritte in der Behandlung des Kesselspeisewassers), E. Gutmann. *Dinglers Polytechnisches Journal*, Vol. 108, No. 3, Feb., 1927, pp. 29-31. Points out that one of the newest and most noteworthy means of preventing boiler scale is known under trade name of Kespurit, which has been in successful use for several years; it is water-soluble colloid enveloping smallest scale-forming constituents, which are thus prevented from wandering as insoluble colloids in boiler.

Treatment — Principle Methods of Boiler Feed-Water Treatment (Kritik der hauptsächlichsten Methoden zur Reinigung von Kesselspeisewasser). *Warme- u. Kälte-Technik*, Vol. 29, No. 4, Feb. 23, 1927, pp. 46-50. Discusses Permutit, lime-soda and Neckar processes.

Thermal Treatment—Thermal Methods of Feed-Water Treatment (Die thermische Speisewasseraufbereitung), R. Blaum. *V.D.I. Zeit.*, Vol. 71, No. 9, Feb. 26, 1927, pp. 285-90, 12 figs. Exhaust-steam evaporator makes no additional demand on boiler and heat content in evaporated steam as regained in feed-water preheater; under these conditions, evaporator ceases to be emergency device and becomes regular element of power plant; author recommends two-stage preheating; in one stage auxiliary steam is available at high pressure, and other at low pressure; degasification of water can be best carried out in mix preheaters; in land installations the most important factor to be considered is the large scale of operation; heat loss in central stations can be kept a good deal below that on shipboard; author shows that it is possible to find proper solution for problem of water distillation, whether boiler is equipped with economizers or regenerators and air preheaters; describes central-station installation where bled steam is used for heating, and water raised to temperature of 65 deg. C. See brief translated abstract in *Mech. Eng.*, Vol. 49, No. 5, May, 1927.

Tri-Sodium Phosphate—Overcoming Boiler-Water Troubles with Tri-Sodium Phosphate, B. C. Sprague. *Power*, Vol. 65, No. 9, Mar. 1, 1927, pp. 321-22, 1 fig. Sulphate waters will not cause adherent scale if enough sodium carbonate is added to maintain certain ratio between carbonate and sulphate in boiler water; at high operating pressures, however, most sodium carbonate decomposes into sodium hydroxide, making it difficult to maintain desired ratio; this difficulty can be avoided by use of tri-sodium phosphate.

Hydrogen-ion Control — Automatic Hydro-ion Control of Boiler Feed Water, Parker, H. C., and Greer, W. N. *Journal Am. Water Wks. Assn.*, 16, 602-16 (1926). *Chem. Absts.*, Feb. 20, 1927, 21, 4, 619. The construction and operation of a continuous pH record are described. The advantages in control of treatment, knowledge of boiler conditions, and proper addition of chemicals that would result from its use are discussed.—D. K. French.

Treatment — Feed-Water Treatment in Power Plants, Anon. *Power Plant Eng.*, 31, 25-9 (1927). *Chem. Absts.*, Feb. 10, 1927, 21, 3, 467. The use of evaporators with deaërators has become general. H_2SO_4 has been successfully used to maintain the proper SO_4: CO_3 ratio. The use of Na phosphate has not always been satisfactory. —K. C. Beeson.

Pretreatment—Joint Research Committee on Boiler Feed-Water Studies Pretreatment of Boiler Feed Water, Knowles, C. R. *Mech. Eng.*, 48, 1361-3 (1926). *Chem. Absts.*, Feb. 20, 1927, 21, 4, 619. Study A: Operation of continuous and intermittent lime-soda water softening plants. The initial cost of the intermittent plant is 30 to 50 per cent higher because of the larger tanks, storage, filters and pumps necessary. Labor is higher for the intermittent plant, but power and other operating costs are about the same. Results under good conditions do not differ. Study B: Economic value of lime-soda softening preliminary to Zeolite softeners. Large installations using high pressures demand pretreatment. For small installations it is not always economical, and for evaporators and cooling systems it is not necessary. Study C: Economic value of lime-soda softening preliminary to evaporators. Waters containing 10 grains or more of total hardness are given pretreatment.—K. C. Beeson.

Treatment—Boiler Feed-Water Treatment by Permutit System, Bahlman, Clarence. Fifth Ann. Rept. Ohio Conference Water Purification, 1925, 64-7. *Chem. Absts.*, Nov. 10, 1926, 20, 21, 3524.—R. E. Greenfield.

Treatment — Modern Practices in Boiler Feed-Water Treatment, Splittgerber, A. *A. angew Chem.*, 39, 1340-5 (1926); *cf. C. A.*, 20, 790. *Chem. Absts.*, 21, 4, 619, Feb. 20, 1927. To protect the boiler from acid corrosion, the alkali content should not be less than 0.4 g./1. of caustic soda or 1.85 g./1. of soda ash. This concentration at 200 deg. gives a pH about 9.4 and is not injurious. Tests on well-made boilers show that rivet-hole fissures are not caused by high concentration of caustic if heavy scale is not present.—K. C. Beeson.

Treatment—Railroad Water Treatment, Coughlan, R. E. *J. Western Soc. Eng.*, 31, 392-4 (1926); *cf. C.A.*, 20, 3758. *Chem. Absts.*, Jan. 10, 1927, 21, 2, 293. Treatment of waters with excess of lime and soda over that required to combine with scale-forming materials is satisfactory in preventing corrosion.—K. C. Beeson.

Treatment—Recent Developments in Feed-Water Treatment, Tenney, E. H. *Power Plant Eng.*, 31, 23-4 (1927). *Chem. Absts.*, Feb. 10, 1927, 21, 3, 467. —K. C. Beeson.

Boilers

Scale—Preventing Formation of Adherent Scale in Steam Boilers, Hall, R. E. U. S. 1,613,656, Jan. 11. *Chem. Absts.*, March 10, 1927, 21, 786. Water used in steam boilers and which contains scale-forming constituents such as Ca and Mg compounds is mixed with a suitable proportion of a substance such as Na_3PO_4, which reduces the tendency to form an adherent scale in the boiler. U. S. 1,613,701 relates to a similar process in which Na_2CO_3 may be used to form non-adherent sludge.

Incrustation — Preventing Incrustation in Boilers, Bologne, G., and Drybusch, W. Brit. 249,431, Oct. 27, 1925. *Chem. Absts.*, March 20, 1927, 21, 974. Zn plates are partly immersed in the water, as are also battens of alder

wood so that the sap may be gradually extracted from the wood.

Scale — Case of Scaling of Boilers Fed with Softened Water and Method of Preventing It, Le Tellier, P., and Sunder, H. *Chimie et industrie* Special No., 241-3 (Sept., 1926). *Chem. Absts.*, March 10, 1927, 21, 785. $CaSO_4$ bearing boiler water which had been softened (presumably in the cold) by the CaO-Na_2CO_3 processes to 4-5 deg. of hardness (French), 0.5-2 deg. NaOH and 3-5 deg. total alkali, caused heavy $CaSO_4$ scaling in a boiler by reversal at high temperature of the reaction taking place in softening (Na_2SO_4 + $CaCO_3$ = Na_2CO_3 + $CaSO_4$). Another water containing but little SO_4 and softened in the same manner, gave but a very thin pulverulent deposit on the tubes in one year. Renewal of the trouble was prevented by adding 0.1 kg. Na_2HPO_4 $0.12H_2O$ per cu.m. as the water was being fed to the boiler. The Ca is eliminated (presumably as $Ca_3(PO_4)_2$) in the form of a fine sludge, requiring rather frequent blowdowns and occasional cleaning out of the boilers, and scaling is practically completely eliminated. To prevent the Na_2CO_3 content from rising above 0.5 g. per l, 0.0175 l of 45 deg. Bé. H_3PO_4 per cu.m. of water was also added.—A. Papineau-Couture.

Scale—Boiler Scale and Its Prevention (Sur un cas d'incrustation des chaudieres alimentees avec de l'eau epuree et le moyen de l'eviter), P. LeTellier and H. Sunder. *Chimie & Industrie*, Vol. 16, No. 3, Sept., 1926, pp. 241-42. Describes process of treating feed water by replacing adequate quantity of sodium phosphate by phosphoric acid.

Steel Embrittlement—Embrittlement of Steel, A. G. Christie. *Am. Water Works Assn. Journal*, Vol. 17, No. 2, Feb., 1927, pp. 174-89. Progress report of Subcommittee No. 6 on embrittlement of metals; certain engineers have been led to conclude that such embrittlement as occurs is promoted by presence of caustic in the waters of the boiler resulting from occurrence of sodium carbonate in feed water; other engineers have concluded that other causes contribute to this type of failure and that presence of caustic is not controlling factor; evidence and reasoning of both schools of thought are summarized; most experimental work carried on has been with waters high in carbonate or bicarbonate of soda.

Evaporators

Bent-Tube Evaporator for Treating Seat Water for Use in Boilers, Jones, R. C. **U. S. 1,617,119, Feb. 8.** *Chem. Absts.*, March 20, 1927, 21, 974.

Distilling Boiler Feed Water, International General Electric Co., Inc. Brit. 247,567, Feb. 10, 1925. *Chem. Absts.*, Feb. 20, 1927, 21, 4, 620.

Evaporator Adapted for Purifying Boiler Feed Water, J. Price. U. S. 1,617,081, Feb. 8. *Chem. Absts.*, March 20, 1927, 21, 974.

Water

Supply—Illinois Central Builds an Automatic Water Supply Station, Anon. *Ry. Maintenance & Eng.*, 22, 230 (1926). *Chem. Absts.*, Sept. 10, 1926, 20, 17, 2885. In connection with the installation of the Markham Yard Terminal facilities near Chicago, the I. C. Railroad constructed at 50,000-gal. per hour electrically operated pumping and softening plant to handle and correct feed water. The softening plant is of the continuous type using orifice and weir proportioning to lower floating cutlet in chemical vat. In addition to 5 hours' sedimentation, 2 open-type gravity sand filters aid in clarification of the treated water before distribution through 5 miles of 14-in. main to six 100,000-gal. storage tanks in the yard. Lime and soda are used for softening. Both raw and treated water pumps, as well as chemical equipment, are controlled automatically by level of water in storage tanks. General plan photographs are shown.—R. C. Bardwell.

Purification — Water Purification, Grant, A. L. Can., 258,297, Feb. 23, 1926. *Chem. Absts.*, Nov. 10, 1926, 20, 21, 3526. $BaSiO_3$ is added to heated water containing $MgCO_3$ to remove scale-forming substances from the water and avoid substitution of foam-producing or soluble salts in the water.

Problems—Water-Treating Problems Encountered in Railroad Practice, Johnson, S. C., *Mec. Eng.*, 48, 1023-4 (1926). *Chem. Absts.*, Jan. 20, 1927, 21, 2, 293. The largest single factor in obtaining satisfactory results is competent supervision in the chemical quality of the raw and treated water and of the mechanical application.—K. C. Beeson.

Apparatus

Oxygen — Recorder for Dissolved Oxygen in Feed Water, Anon. *Engineering*, 122, 610 (1926). *Chem. Absts.*, Jan. 20, 1927, 21, 2, 293.—K. C. Beeson.

Deaërating—Apparatus for Deaërating Boiler Feed Water. Elliott, W. S. Britt. 247,342, Dec. 18, 1924. *Chem. Absts.* Feb. 20, 1927, 21, 4, 620.

Treatment—Apparatus for Treating Boiler Feed Water. Babcock & Wilcox, Ltd., and Spyer, A. Brit. 245, 664, June 16, 1925. *Chem. Absts.* Jan. 20, 1927, 21, 2, 294. A de-aerator, evaporator, liming apparatus and filter are provided.

Increased (water-treatment) Facilities Serve Double Track. Turner, F. P. Ry. Rev., 78, 557 (1926). *Chem. Absts.*, Sept. 10, 1926, 20, 17, 2886. In the course of double-tracking the Norfolk & Western Ry. between Naugatuck and Kenova, W. Va., new modern pumping station and water-softening plant were included in the Prichard, W. Va., terminal facilities. Duplicate electric centrifugal pumping units delivered raw water from the Big Sandy River to a 60,000-gal.-per-hour continuous softener of the tipping-bucket control type. After 5 hour sedimentation an excelsior filter in the top of the softening tank aids in clarification. Revolving sludge remover driven by worm gear is used. A 200,000-gal. elevated steel tank provides treated-water storage. Discussion of construction problems is accompanied with plans and photographs.—R. C. Bardwell.

Inspection—Report of the Bureau of Boiler Inspection. Smith, Wm. E., Proc. Hawaiian Sugar Planters Assoc., 45th Ann. Meeting 1925, 1-20 (1926); cf. C. A. 20, 1291. *Chem. Absts.*, March 10, 1927, 21, 785.—K. D. Jacobs.

Lime—Slaked Lime and Unslaked Lime—Bardwell, R. C., and Rees, O. T. Ry. Maintenance and Eng. 22, 2-71 (1926). *Chem. Absts.*, Sept. 10, 1926, 20, 17, 2887. Advantages in use of hydrated lime for railway water softening are (1) convenience in handling; (2) avoidance of slaking equipment expense; (3) less expensive storage facilities; (4) more uniform strength; (5) less objectionable impurities. Advantage in use of unslaked lime is in lower first cost of material only.—R. C. B.

Compensation for Injury Received in "Horseplay"

By Leo T. Parker

In view of the fact that there has been considerable controversy whether or not an employee is entitled to compensation for injuries received while indulging in moments of play, it is interesting to note that various higher courts have held in the affirmative.

For example, in the case of Pekin Cooperage Co. vs. Industrial Board (277 Ill. 53) the Supreme Court of that State allowed Garis, an employee, compensation. The facts, as stated by the court, were:

"On November 1, 1913, he quit work about 5 o'clock and formed in line with the other employees to receive his weekly pay at the office window as he passed out of the building. There were about 75 men in line, and Garis occupied a position about the middle of the line. Some of the men behind Garis began pushing backward at the same time, and Garis was squeezed out of the line and slipped or stumbled and fell upon the cement floor and received the injuries of which he complains."

The court held the employee entitled to compensation and said:

"There can be no serious contention that the injury did not arise out of his employment. Garis was required to present the slip given him at the window in the office of plaintiff in error to receive his pay. Complying with this regulation and standing in line waiting his turn he was jostled and thrown down and injured through no fault of his own. It does not appear that he was engaged in any jostling or 'horseplay' or that he was in any way responsible for the injury he sustained."

The case of Hollenbach Co. vs. Hollenbach (204 S.W. 152, 181 Ky. 262, 13 A.L.R. 524) is quite interesting. It is a decision by the court of last resort in that state. This court said:

"The point is made that Hollenbach, or one of his fellow workmen, in the basement, placed the wire in the position it was at the time of the accident in order to play a practical joke on any person attempting to make use of the wash basin, and that this was foreign to the employment and therefore no recovery can be had under the act. Ordinarily, one injured while engaged in horseplay, in perpetrating a practical joke, or in some frolicsome prank, is not entitled to compensation under the act, but there are exceptions to this general rule. One exception is where the injured employee is at his usual employment and not engaged in the play or joke, and the injury is caused by the sporting act of his fellows."

News in the Field of Power

Refrigerating Engineers To Enjoy Varied Program at Spring Meeting

Gathering to Be Held at White Sulphur Springs—Inviting Papers and Entertainment Features Listed—To Join A.S.M.E. in Annual Spring Banquet

THE American Society of Refrigerating Engineers will hold the fourteenth spring meeting of its members at White Sulphur Springs, W. Va., May 23 to 25, inclusive. The various technical sessions and entertainment features will center at the Greenbrier Hotel.

On Monday, May 23, the opening session in the morning will be devoted to the registration of members, in concurrence with that of the A.S.M.E. roll call, following which the reading of the minutes of the annual convention, reports on the election of members, work of committees and other business will take place. R. P. Russell, of the Massachusetts Institute of Technology, will present the report of the committee on corrosion. Certain physical and chemical properties of methyl chloride will be described by H. J. Macintire, C. S. Marvel and S. G. Ford of the University of Illinois, Urbana, Ill.

E. S. Schenck, Brunswick-Kroeschell Co., New Brunswick, N. J., will read a paper on manufacturing costs.

Technical Papers Slated

The evening session will be devoted to a study of the factors affecting the capacity and efficiency of small reciprocating compressors. These factors will be described by L. A. Philipp, of the University of Michigan, Ann Arbor, Mich., and C. C. Spreen, Kelvinator Corp., Detroit, Mich. "The Gas-Fired Refrigerator," by F. E. Sellman, mechanical engineer, Electrolux-Servel Corp., New York City, and "Air Conditioning in the Theater" will be discussed by L. L. Lewis, Carrier Engineering Corp., Newark, N. J. "Balancing Power and Condenser Water Costs," by R. W. Waterfill, Carrier Engineering Corp., Newark, N. J., will close the session.

Five papers will be studied at the afternoon session of Tuesday, May 24. "The Effect of Compressor Speed Upon Refrigerating Capacity and Efficiency," by C. C. Spreen and L. A. Philipp. "A Comparison of Various Refrigerants for Small Units," by J. R. Hornaday, Pennsylvania State College. "A Method for Testing Domestic Refrigerating Machines," by C. D. Haven, Milwaukee, Wis. "The Effect of Cold Storage on Clothes Moths" will be discussed by E. A. Bach and E. A. Cotton, Bureau of Entomology, Department of Agriculture, Washington, D. C. "Characteristics of Centrifugal Pumps" will be described by J. J. Meeker representing the Hydraulic Society of New York City. "A Comparison of Standard Flow Meters," by A. J. Nicholas of the Pennsylvania State College, will also be read. In the evening the council will meet.

Presentation of two papers will be made Wednesday afternoon. They are: "Factors Governing Liquefaction of Carbon Dioxide," by J. C. Goosman, Frick Co., Waynesboro, Pa. "The Effect of Moisture on the Heat Transmission in Insulating Materials," by L. F. Miller, department of physics, University of Minnesota, Minneapolis, Minn.

Ball Game with A.S.M.E.

Entertainment features will be amply provided for the attending members and lady visitors. Tuesday afternoon golf and tennis tournaments and a motor drive and tea will be held, and in the evening a bridge tournament, photoplay and dancing. A baseball game between the A.S.M.E. and the A.S.R.E. is slated for the following afternoon.

Joining the A.S.M.E., the society will attend the annual spring dinner Wednesday evening, at which Wilfred Lewis will be awarded a medal by the mechanicals, and tournament prizes will be given out. A bridge tournament and water carnival are also on the program.

Iowa Public Service Co. Buys Two Utilities for Merger

The Iowa Public Service Co., recently organized, acquired May 1 the Central Iowa Power & Light Co. and the Iowa Light, Heat & Power Co. The new company is directly under United Gas Improvement management.

The merged companies were under U.G.I. supervision and control, operating in the same and adjacent territories, and their consolidation into one company makes a more compact and efficient organization, from both the viewpoints of operation and financing, according to report.

The Iowa Public Service Co. serves 200 communities with electricity and four with gas in 34 counties of western and north central Iowa. These communities, with a total population of approximately 500,000, include Sheldon, Cherokee, Quimby, Storm Lake, LeMars, Sac City, Ida Grove, Rockwell City, Audubon, Rutland, Emmetsburg, Spirit Lake, Eagle Grove, Hampton, Charles City and Waterloo. A small water and steam-heat business will also be carried on.

Practically all of the various generating stations are interconnected, and in addition the territory is tied in with the Big Sioux power plant of the Sioux City (Iowa) Gas & Electric Co. by a 66,000-volt high-tension transmission line.

The officers of the Iowa Public Service Co. are: D. M. Sterns, president; G. A. Neal, F. J. Rutledge, W. H. Taylor, vice-presidents; W. N. Porter, secretary, H. B. Maynard and John Hopkins, assistant secretaries; L. W. Wade, treasurer; E. MacMorris and J. B. Townsend, 3rd, assistant treasurers.

The directors are: W. W. Bodine, G. W. Curran, P. H. Gadsden, J. T. Hutchings, F. J. Rutledge, D. M. Sterns and W. H. Taylor.

The local headquarters of the new company is at Fort Dodge, Iowa.

National Museum of Engineering Holds Annual Meeting

The National Museum of Engineering and Industry held its third annual meeting at its headquarters in the Engineering Societies Building, 29 West 39th St., New York City, on Thursday afternoon, April 28 at 4 o'clock.

Preliminary to the meeting the members tendered a luncheon at the adjoining Engineers Club to the presidents and secretaries of the following societies who were represented on its board of trustees: American Society of Civil Engineers, American Institute of Mining and Metallurgical Engineers, American Society of Mechanical Engineers, American Institute of Electrical Engineers, United Engineering Society, Engineering Foundation, Engineers Club, American Engineering Council, Society for the Promotion of Engineering Education, American Chemical Society and the American Association for the Advancement of Science.

The Smithsonian Institution of Washington, D. C., of which the National Museum of Engineering and Industry will be a part, and the Museum of the Peaceful Arts of New York City, were also represented.

Trustees Elected

The following trustees were elected: L. P. Alford, B. C. Batcheller, George M. Bond, Nicholas F. Brady, Ericsson F. Bushnell, Fred H. Colvin, F. A. Halsey, Thomas T. Hoopes, Prof. D. C. Jackson, Joseph Keller, Fred R. Low, H. P. Merriam, H. F. J. Porter, Dr. M. I. Pupin, Dr. Elmer A. Sperry, Kirby Thomas and F. A. Waldron.

Thomas Ewing, former Commissioner of Patents, is president, and Mr. Harrison W. Craver, librarian of the United Engineering Societies Library, secretary.

Representing the Smithsonian Institution, Carl W. Mitman, displayed a chart of the Mall in Washington, D. C., illustrating the location of the proposed museum building.

Philadelphia Electric Acquires Three in Merger

The Philadelphia Electric Co. has entered into a contract for the purchase of the Eastern Power Co., the Southern Pennsylvania Power Co. and the Northern Maryland Power Co., formerly owned and controlled by John Ware, Jr.

It is the intention of the Philadelphia Electric Co., according to report, to supply the territory in which the above-named companies operate from Conowingo, as soon as this hydro-electric plant is in operation, early next year. In the meantime, improvements to the transmission and distribution lines and substations will be undertaken in order to provide and insure continuity of service, it being the aim of the Philadelphia Electric Co. to extend to its future customers the same standard of service as it does in Philadelphia.

The Eastern Power Co. is a holding company. The Southern Pennsylvania Power Co. operates in the towns of Russellville, Cochraneville and Oxford. The Northern Maryland Power Co. acquired the property of the Elkton Electric Co., Northern Maryland Electric Co., Home Manufacturing Light & Power Co. and the Havre de Grace Electric Co.

A.I.E.E. Makes Ready for Summer Convention

A well balanced list of papers, and a full program of attractive recreational features, will mark the coming summer convention of the American Institute of Electrical Engineers, which will be held in Detroit in the Book-Cadillac Hotel, June 20-24.

For the technical sessions, a large number of papers on practical operating subjects have been chosen, in addition to some of the latest scientific and theoretical contributions. These papers include such subjects as power stations, transmission-line operation, relays, control circuits, cable joints, communication, dielectrics, corona, rectifiers, electrical units and electric traction.

Practically all fields of electrical engineering will be covered in the reports of the technical committees, which are scheduled for presentation on Wednesday morning, June 22.

Five Maryland Power Co.'s Are Consolidated

An applicatino for the recognition of the combination of five power companies in Maryland has been made recently to the Public Service Commission of Maryland.

The power merger brings into a single corporation the Elkton Electric Light Co., the Home Power Co., of Chesapeake City; the Havre de Grace Electric Co.; the Gilpin Falls Electric Power Co., and the Perryville Electric Company.

The name of the new organization is the Northern Maryland Power Co. C. R. Powell has been made general manager of the merged companies. Former Sheriff J. Wesley McAllister is manager of the lines in Cecil county. Mr. Powell states that the merger will control the entire electric power distribution throughout Cecil County and a part of Harford County.

Canadian Boiler Inspectors Meet to Amend Code

Chief inspectors of steam boilers assembled from the nine provinces of Canada May 9 to attend the annual convention on regulations and inspection which met at the offices of the Chief Inspector of Steam Boilers, Department of Labour, Toronto, Ontario.

For some time a growing interest has been manifest throughout the country in bringing about amendments in the interprovincial regulations, so that they will be more closely in line with the Boiler Code of the American Society of Mechanical Engineers. To this business, supported among other engineers by D. M. Metcalf, chief inspector of Ontario, the convention turned its attention.

Whole Colorado Project on Review for Next Congress

Five major questions for solution on the development of the Colorado River have been submitted by Secretary Work of the Interior Department to his special advisers.

Upon these chiefly he wished the investigation to be based. They are:

1. Whether the Federal government by control of water rights has the power to allocate the unappropriated waters of the Colorado River to the basin states and make unnecessary a compact between the states.

2. Where the most feasible site is for a dam, now proposed in Black Canyon and known as the Boulder Dam site.

3. What the international situation is in relation to the canal now supplying Imperial Valley with water through Mexico and what rights Mexico might have when a storage dam is built.

4. Just what benefits the lower basin states will receive from the control of silt and storage of water by the proposed dam.

5. Whether or not it is vitally necessary that all revenues from power be confined to repayment to the government of the cost of the dam.

Deals With Whole Problem

These major questions make it clear that the advisors will deal with the Colorado River question as a whole and will not confine their work to the Boulder Canyon dam, as some would like. The letter of notification of appointment which went to each advisor, however, contains the statement that it is the desire of Secretary Work "to submit a report to Congress at the forthcoming session, based on your findings, covering the essential features of the Swing-Johnson bill now before that body and the probabilities of reimbursements to the government for its expenditures in this connection."

Those on the staff of advisors are: James G. Scrughum, Frank C. Emerson, James R. Garfield, William F. Durand and Charles W. Waterman.

An effort is being made to induce Secretary Work to appoint other advisors. It is felt that those already named, with the exception of Mr. Garfield, are parties to the Colorado River controversy. At the same time it is recognized that if these advisors should differ with the plan proposed by Senator Johnson and Representative Swing, that it would have much more weight than were it to come from persons known to be in opposition to the Boulder Dam project.

Power Survey in Three States Planned

A power survey of the Rocky Mountain territory, including Colorado, Wyoming and New Mexico, which may change the industrial map of the region, is planned, according to report.

It has been pointed out the trend of industry is away from large cities and that in future years population and industry will center around natural resources where dependable power facilities are always at hand.

The possible survey would be made by electrical experts.

Oklahoma Utility Merger

Acquisition of all of the properties of the Oklahoma Power Co. by the Public Service Company of Oklahoma was announced recently. Thirty-four communities in southeastern Oklahoma will be added to those already served by the latter company as a result.

Personal Mention

Matthew S. Sloan, president of the Brooklyn Edison Co., was elected May 5 as a member of the Board of Directors of the Chamber of Commerce of the United States.

A. K. Warren is on the seas for Japan to continue his work as consulting engineer for the Shibaura Engineering Works, which is an affiliated plant of the General Electric Co.

Rene Boulassier, for the past three years connected with Lavoix, Moses & Gehet, patent attorneys, of Paris, France, is now in business for himself as consulting and patent engineer at offices in the same city.

Society Affairs

A.S.M.E., Chicago, annual dinner and election of officers, May 11; "The Important Part the Engineer Will Play as an Administrator in Public Service and Manufacturing Activities," by Dr Walter Dill Scott, president of Northwestern University, and "Training in the Engineering College for Leadership in Industry," by Dean A. A. Potter, Purdue University.

A.S.M.E., Baltimore, Engineers Club at 8:15 p.m.; "Oil Burners for Domestic House Heating," by Arthur H. Senner, assistant mechanical engineer, division of agricultural engineering, Bureau of Public Roads.

Business Notes

The Lincoln Electric Co., Cleveland, Ohio, announces the appointment of Royal D. Malm as Western district sales manager, with headquarters at Chicago.

The William Ganschow Co., Chicago and Peoria, announces the appointment of Fred E. Holtz as representative in the Milwaukee territory. The division headquarters will be located at 1246 24th Avenue, Milwaukee, Wis.

The Whiting Corp., cranes-foundry equipment, appointed recently as sales agents Brazelton, Wessendorff & Nelms, Inc., 317 Preston Avenue, Houston, Tex. This firm will handle the complete Whiting line of cranes, foundry equipment and railroad specialties, in southeastern Texas.

The General Electric Company announces a new float switch bearing the designation CR-2931-P for use in control circuits only. This switch, in general, will be used to control the line contactor of alternating- or direct-current automatic starters. It has a capacity for handling one 600-ampere, two 300-ampere or four 150-ampere a.-c. or d.-c. contactors at from 110 to 550 volts.

The Quigley Furnace Specialties Co., Inc., of New York, manufacturers of Hytempite, Quigley refractory gun, Triple-A solutions, Quigley acid proof cement, etc., announces that Harrison W. Wood has joined the service staff of the company. He will cover the Central South and South Atlantic States. Mr. Wood has been identified with the manufacturing and sales departments of large industrials throughout the territory he now covers for the Quigley company. Making his headquarters at Atlanta, Ga., he will co-operate with all Quigley agents throughout the Central and South Atlantic States.

The Westinghouse Electric & Manufacturing Co. announced recently the appointment of J. P. Alexander as Boston manager in charge of all sales and service in New England. During the twenty years that he has been associated with Westinghouse, Mr. Alexander has become a prominent figure in the electrical industry in New England. He was made manager of the transportation division at Boston in September, 1922, and manager of the New Haven, Conn., branch office in 1924, which latter position he leaves to return to Boston as district manager.

The Yeomans Brothers Co., 1433 Dayton St., Chicago, Ill., manufacturers of sewage ejectors and pumping machinery, announce as three new representatives, Texas Engineering Co., 925 Electric Bldg., Houston, Tex., Dillard Engineering Co., 612 Construction Industries Bldg., Dallas, Tex., Heating & Ventilating Equipment Co., Builders & Traders Exchange, Lyon St. & Ionia Ave. N. W., Grand Rapids, Michigan. These representatives will handle the complete Yeomans line which includes sewage ejectors, bilge pumps, house pumps and condensation return pumps.

Coming Conventions

American Association of Engineers. Annual convention, Tulsa, Okla., June 6-8; M. E. Melver, 63 East Adams St., Chicago.

American Boiler Manufacturers Association. Annual meeting at French Lick Springs Hotel, French Lick, Ind., May 30-June 1.

American Institute of Electrical Engineers. F. L. Hutchinson, secretary, 33 West 39th St., New York City. Pittsfield, Mass., regional meeting May 25-27. Summer convention at Detroit, Mich., June 20-24 inclusive; Pacific Coast convention at Del Monte, Calif., Sept. 13-16.

American Order of Steam Engineers. Annual convention, Moose Hall, 1314 North Broad St., Philadelphia, Pa., June 13-16; J. E. Burke, 1821 So. Ringgold St., Philadelphia.

American Refractories Institute. Spring meeting at Hotel Traymore, Atlantic City, N. J., May 18-19; D. A. Texter, secretary, 2202 Oliver Bldg., Pittsburgh, Pa.

American Society of Civil Engineers. George T. Seabury, secretary, 33 West 39th St., New York City. Annual convention at Denver, Col., July 13-15.

American Society of Mechanical Engineers. Spring meeting at White Sulphur Springs, W. Va., May 23-26. Calvin W. Rice, secretary, 33 West 39th St., New York City.

American Society of Refrigerating Engineers. Western meeting at White Sulphur Springs, W. Va., May 23-25, in conjunction with the Spring meeting of the A.S.M.E.; W. H. Ross, 35 West 39th St., New York City.

American Society for Testing Materials. Annual convention at French Lick Springs Hotel, French Lick, Ind., June 20-24; J. K. Rittenhouse, secretary, 1315 Spruce St., Philadelphia, Pa.

American Water Works Association. W. M. Niesley, assistant secretary, 170 Broadway, N. Y. Annual convention Hotel Sherman, Chicago, June 6-11.

Association of Iron and Steel Electrical Engineers. Annual convention at Pittsburgh, Pa., June 13-18, inclusive.

National Association of Practical Refrigerating Engineers. Annual convention probably in November; E. H. Fox, 5707 W. Lake St., Chicago, Ill.

National Association of Stationary Engineers—Annual convention at Ambassador Hotel, Los Angeles, Calif., Aug. 22-27; John Topman, secretary, convention committee, Ohio State annual convention in Memorial Hall, Lima, Ohio, June 16-18; P. H. Grigsby, secretary, Lima, Ohio. New England States convention at Portland, Me., June 17-18; Thomas H. Clark, president, Worcester, Mass.; Robert Johnson, secretary, 65 Charlotte St., Worcester, Mass. Indiana State convention and power show at Anderson, May 27-28. Plainfield, N. J., meeting at Academy Hall, June 3-5.

National Board of Boiler and Pressure Vessel Inspectors. Annual meeting at Nashville, Tenn., June 14-16 inclusive.

National District Heating Association. Annual convention at West Baden Springs Hotel, West Baden, Ind., May 17-20, inclusive; D. L. Saskill, secretary, Greenville, Ind.

National Electric Light Association. A. Jackson Marshall, secretary, 29 West 39th St., New York City. Convention at Atlantic City, June 6-10; exhibition, June 4-10.

Universal Craftsmen Council of Engineers. Thomas H. Jones, secretary, 33 Linden Ave., Cherrydale, Va. Annual convention at Buffalo, N. Y. Aug. 2-6.

The Graybar Electric Co. announces the appointment of G. E. Chase to the office of high tension sales manager. In 1919 Mr. Chase was transferred to the scheduling division of the Western Electric as schedule engineer, and in 1921 was appointed broadcasting sales engineer of the Western Electric supply department. He continued in this capacity until January, 1926, when the Graybar Electric Co. succeeded the Western Electric supply department and he became broadcasting sales manager of Graybar.

Fuel Prices

COAL

The following table shows the trend of the spot steam market in various coals, f.o.b. mines; mine run except Pittsburgh gas slack:

Bituminous Net Tons	Market Quoting	May 2 1927
Pool 1	New York	$2.75@$3.00
Smokeless	Boston	1.70
Clearfield	Boston	1.60@ 1.90
Somerset	Boston	1.70@ 2.10
Kanawha	Columbus	1.50@ 1.75
Hocking	Columbus	1.60@ 1.75
Pittsburgh	Pittsburgh	2.25
Pittsburgh gas slack	Pittsburgh	1.60@ 1.75
Franklin, Ill.	Chicago	2.50@ 2.75
Central, Ill.	Chicago	2.25@ 2.50
Ind. 4th Vein	Chicago	2.40@ 2.50
West Ky.	Louisville	1.60@ 1.75
S. E. Ky.	Louisville	1.50@ 1.75
Big Seam	Birmingham	1.50@ 2.00
Anthracite Gross Tons		
Buckwheat No. 1	New York	2.65@ 3.60
Buckwheat No. 1	Philadelphia	2.50@ 3.00
Birdseye	New York	1.35@ 1.60

FUEL OIL

New York—May 5, light oil, tank-car lots; 28@34 deg. Baumé, 5½c. per gal.; 36@40 deg., 5¾c. per gal. f.o.b. Bayonne, N. J.

St. Louis—April 27, tank-car lots, f.o.b. St. Louis; 24@26 deg., $1.75 per bbl.; 26@28 deg., $1.80 per bbl.; 28@30 deg., $1.85 per bbl.; 30@32 deg., $1.90 per bbl.; 32@36 deg., gas oil, 4.5c. per gal.; 38@40 deg., 5.5c. per gal.

Pittsburgh—April 28, f.o.b. local refinery; 30@34 deg., fuel oil, 6½c. per gal.; 36@40 deg., fuel oil, 6.5c. per gal.

Philadelphia—April 27, 27@30 deg., $2.31@$2.37 per bbl.; 13@19 deg., $1.89 @$1.95 per bbl.

Cincinnati—April 25, tank-car lots, f.o.b. local refinery, 24@26 deg. Baumé, 6½c. per gal.; 26@30 deg., 6¾c. per gal.; 30@32 deg., 7c. per gal.

Chicago—April 30, tank-car lots, f.o.b. Oklahoma, freight to Chicago, 92c. per bbl.; 24@26 deg., $1.05 per bbl.; 26@30 deg., $1.10; 30@32 deg., $1.20.

Boston—May 2, tank-car lots, f.o.b. 12@14 deg. Baumé, 4.44c. per gal.; 28@ 32 deg., 5.85c. per gal.

Dallas—April 25, f.o.b. local refinery, 26@30 deg., $1.45 per bbl.

The American Brass Co. opened an office in the Military Park Building, Newark, N. J., May 2. J. B. Benedict and L. B. Smith are in charge and will handle the complete line of Anaconda copper, brass and bronze products.

Wm. B. Scaife & Sons Co. of Pittsburgh, Pa., have moved their New York office from 26 Cortlandt Street where it has been for 20 years. The new office is in the Architects Building at 101 Park Avenue. Metropolitan district sales of the company's various products are handled from this office by H. F. Reynolds, manager.

Baker & Spencer, Inc., announce that R. G. Adams joined that organization May 1, in charge of the contract department. His previous connections were with McClellan & Junkersfeld, Inc., the American Sugar Refining Co., Royal Flying Corp., and previous to the war with the Babcock & Wilcox Co., Bethlehem Steel Co., and the Combustion Engineering Corporation.

Trade Catalogs

Tabco Dust Removal System.—A. C. Nielsen Co., Chicago, has issued in circular form the report of a special survey of the Tabco pneumatic system of dust removal, installed in the Big Sioux Station of the Sioux City Gas & Electric Co., Sioux City, Iowa.

Seamless Steel for High Pressure and Temperature Requirements. — Seamless Steel Equipment Corp., 26 Broadway, New York City, has issued a catalog illustrating seamless steel products as manufactured by the forged, pressed, drawn and rolled, and pressed and drawn processes.

Electric Furnace Steel Castings.—The Lebanon Steel Foundry, Lebanon, Pa., has published the fifteenth of a series of bulletins on the subject of electric furnace steel castings. This one describes the work of the finishing department in the removal of sand, scale and excess metal.

Stationary Oil Engines. — Ingersoll-Rand Co., 11 Broadway, New York City, in a highly illustrated circular, No. 10008, considers stationary oil engines, vertical, multi-cylinder, four-stroke-cycle, manufactured by the Rathbun-Jones Engineering Co. exclusively for the Ingersoll-Rand Co. Design, construction and operation are gone into with some detail.

Marine Oil Engines.—The Ingersoll-Rand Co. has issued a bulletin depicting Price-Rathbun marine oil engines, vertical, multi-cylinder, four-stroke cycle.

Burning Pulverized Coal Under Steam Boilers—The Combustion Engineering Corp., 200 Madison Ave., 35th St., New York City, has reprinted in full "Recent Developments in Burning Powdered Coal Under Steam Boilers," by Henry Kreisinger, a paper read before the International Conference on Bituminous Coal at Pittsburgh, Pa., Nov. 16, 1926. Copies may be had by writing to the company.

Vertical Diesel Engines—The De La Vergne Machine Co. has prepared a technical supplement to the recently published vertical engine catalog in the form of a bulletin which presents the De La Vergne vertical solid-injection engine and conveys in a concise and clear manner a description of the design, construction and operation of this product. Many photographs of installations are included, adding much illustrative value to this bulletin.

New and Used Power Equipment.—The Ross Power Equipment Co., Indianapolis, Ind., lists among its new and used power equipment, steam and electrical, rock crushers, engines, kilns, boilers, pulverizers, pumps, heaters, heat exchangers, bridge cranes, compressors, machine tools, shovels, condensers, Corliss automatic engines, etc., with many special items for sale at second hand.

New Plant Construction

Ark., Leachville—City is having plans prepared for improvements to waterworks and sewage systems including sewage disposal plant and pumping station, tank on tower, etc. Estimated cost $60,000. A. C. Moore, Joplin National Bank Bldg., Joplin, Mo., is engineer.

Calif., Los Angeles—Childrens' Hospital Assn., is receiving bids for the construction of a hospital and nurses home including steam heating and refrigeration systems, elevators, etc. at Sunset Blvd. and Vermont Ave. Estimated cost $600,000. L. H. Hibbard, Metropolitan Bldg., is architect.

Calif., Visalia — Knudsen Laboratories Inc., 1965 Santee St., Los Angeles, awarded contract for the construction of a creamery and power plant to G. A. Graham, Dinuba, Estimated cost $45,000.

Calif., Williams—City plans an election to vote $38,000 bonds for waterworks improvements including wells, pumping plants, etc.

Ill., Chicago—La Salle Club, 30 North La Salle St., is having preliminary sketches made for the construction of a 30 story office and club building at Wells St. and Wacker Dr. Estimated cost $3,000,000. Vitzthum & Burns, 307 North Michigan Ave., are architects.

Ill., Chicago—E. F. Techmer, 2441 Sunnyside Ave., awarded contract for masonry, etc. for a 12 story hotel at 6151 Winthrop Ave. Estimated cost $1,081,000. W. Bernhard & Co., 820 Tower Ct., are architects.

Ill., Chicago—H. Zisook, 1209 East 55th St., is receiving bids for the construction of a 12 story apartment including central refrigeration plant, elevators, etc. at 5332 Sheridan Rd. Estimated cost $2,000,000. T. R. Bishop & Son, 35 South Dearborn St., are architects.

Ind., Garrett — Common Council, C. W. Bowers, Clk., will receive bids until May 13, for the construction of an engine room, etc. in connection with electric light plant and waterworks.

Ind., Terre Haute—Terre Haute Hotel Co., Fairbanks Estate, will receive bids until May 21 for the construction of a 10 story hotel including refrigeration and ventilation systems, boilers, pumps, elevators, etc. Estimated cost $1,000,000. W. E. Russ, Meridian Life Bldg., Indianapolis, is architect. The Seventh Street Hotel Co., Chicago, Ill., is lessee.

Kan., Osawatomie—Missouri Pacific R.R. Co., Railway Exchange Bldg., St. Louis, Mo., awarded contract for the construction of a 450 ton electrically-operated coaling plant and 100 ton auxiliary station here. to Fairbanks Morse Co., 900 South Wabash Ave., Chicago, Ill.

Mass., Arlington (Boston P.O.)—Arlington Gas Light Co., 689 Masachusetts Ave., awarded contract for the construction of a compressor room and boiler house on Grove St. to Arlington Construction Co., 313 Broadway. Estimated cost $40,000.

Mass., Boston—Boston City Hospital, will receive bids until May 20 for the construction of addition to boiler house on Albany St.

Mass., Gloucester—Bd. of Sewerage Survey, City Hall, will soon award contract for the construction of a pumping station at Cut Bridge. Fay, Spofford & Thorndike, 44 Bromfield St., Boston, are engineers.

Mass., Wakefield—Town plans the construction of a filtration plant and pumping station, equipment, etc. Estimated cost $182,000.

Mass., West Springfield (Springfield P.O.)—United Electric Light Co., L. J. Scott, Gen. Mgr., State & Bliss Sts., Springfield, plans the construction of a switch house and transformer station here. Estimated cost $600,000.

Mich., Fordson—City, B. P. Esper, Clk., will soon award contract for the construction of a pump house including two motor driven centrifugal pumps, etc. for grade separation for depressing street under 4-track railway bridge. Hubbell, Hartgering & Roth, 2640 Buhl Bldg., are engineers.

Miss., Biloxi — U. S. Property and Disbursing Officer, will receive bids until May 26, for drilling of well, constructing a sewage disposal plant and electric light plant, etc. in connection with proposed store and bathhouses.

Mo., Florissant—St. Stanislaus Seminary, Howdershell Rd., awarded contract for the construction of a boiler house, to Hercules Construction Co., Wainwright Bldg., St. Louis. Estimated cost $40,000.

Mo., Nevada—Missouri Pacific R.R. Co., Railway Exchange Bldg., St. Louis, awarded contract for the construction of a boiler house here to H. O. Hirsch & Co., Wainwright Bldg., St. Louis. Estimated cost $10,000.

Mo., Piedmont—Black River Hydro Electric Co., c/o W. H. Meredith, Poplar Bluffs, will receive bids about June 28, for the construction of a hydro-electric plant and dam, 140 ft. high and 2,000 ft. long on the Black River here, to develop 10,000 kw. hp. and form lake of 22,000 acres. Estimated cost approximately $4,000,000. W. A. Fuller, 1927 Railway Exchange Bldg., St. Louis, is engineer.

Mo., St. Louis—Bd. of Public Service, J. Pritchard, Dir., 208 City Hall, will receive bids until May 31 for the construction of a service building including central heating plant, etc. on Clark Ave. Estimated cost $825,000. Study & Farrar, Arcade Bldg., are architects.

Mo., St. Louis—Missouri Pacific R.R. Railway Exchange Bldg., will soon award contract for the construction of a 22 story office building including boiler house, etc. at 13th Pine and Olive Sts. Estimated cost $2,000,000. E. M. Tucker, c/o owner and Mauran, Russell & Crowell, Chemical Bldg., are architects. E. A. Hadley, is chief engineer.

Neb., Bridgeport—E. C. Carter, Bruning, and T. H. Carter, Hebron, are having plans prepared for the construction of a hydro-electric plant on Belmont Canal, 5 mi. down North Platte River from Belmont

dam including two 500 kw. units, and will install a 1,000 kw. unit later. Owner has entered into a contract with the Belmont Irrigation Co. to use canal and raise dam from 2 to 4 ft. Estimated cost $107,000. Private plans.

N. J., North Bergen—Township Committee, E. A. Ryan, Clk., Township Hall, will receive bids until May 12, for the construction of a sewage pumping station, etc.

N. Y., Niagara Falls—Certain-teed Products Co., 100 East 42nd St., New York will soon receive bids for the construction of a power plant here.

Okla., Bison—City is having preliminary plans prepared for improvements to waterworks and distribution systems including pumping station, etc. Estimated cost $18,000. C. Snow, Mayor.

Okla., Purcell—City voted $80,000 bonds for the construction of an 800 hp. Diesel engine electric light plant. Engineer not announced.

Pa., Bryn Mawr—Bryn Mawr Hospital, c/o Hinklesmith, Liberty Bldg., Philadelphia, awarded contract for the construction of two 6 story hospital buildings here to Stone & Webster, Real Estate Trust Bldg., Philadelphia. Estimated cost $1,750,000.

Pa., Philadelphia — Bellvue-Stratford, Broad and Walnut Sts., plans the construction of a hotel including refrigeration system, electric elevators, etc. Estimated cost $1,000,000. T. M. Kirkpatrick, 220 South 16th St., is architect.

Pa., Philadelphia — Bureau of Yards, Docks, Navy Dept., Washington, D. C., plans the construction of an automatic refrigeration and cold storage plant at Navy Yard, also awarded contract for a heating plant at Marine Barracks here to Almirall & Co., Inc., 53 Park Pl., New York, N. Y. Estimated cost $79,676.

Pa., Stroudsburg—Skytop Lodges, c/o Bossiter-Muller & M. Foster, 15 West 38th St., New York, N. Y., Archts., plans the construction of a hotel including steam heating and ventilation systems, boilers, elevators, etc. near here. Estimated cost $800,000.

Tenn., Nashville—Nashville Railway & Light Co., J. P. W. Brown, V. Pres. and Gen. Mgr., First St., plans the construction of addition to steam power plant on the Cumberland River, to increase the capacity. Estimated cost $750,000.

Tex., Amarillo—Davison Hotel Corp., awarded contract for the construction of a 17 story hotel at 8th and Tyler Sts. to Hughes-O'Rourke Construction Co., 613 Oliver-Eaekle Bldg. Estimated cost $2,200,000. Contractor will receive sub-bids until May 15 for steam heating, refrigeration and ventilation systems, boilers, pumps, elevators, etc.

Tex., Corpus Christi—Nueces Hotel, is receiving bids for the construction of a mechanical building including private light plant, refrigeration and ice plants, boilers, generators, etc. in connection with proposed addition to hotel. Total estimated cost $275,000. Adams & Adams, c/o Builders Exchange Bldg., San Antonio, are architects.

Tex., Girvin—Pecos Valley Utilities Co., McCamey, subsidiary of the Kansas City Light & Power Co., 14th St. and Grand Ave., Kansas City, Mo., plans the construction of a hydro-electric plant and dam on the Pecos River near here, cost $1,000,000 and has entered into a contract with companies operating in Crane-Upton and Reagan oil fields to electrify their well drilling and pumping equipment. A system of transmission lines will be constructed in an area of 100 mi. around the proposed plant, cost about $250,000. Private plans.

Tex., Jacksonville—City will build a sewage disposal plant and pumping station. Estimated cost $65,000. H. L. Thackwell, City Hall, is engineer.

Tex., Perryton — City, F. P. Rodger, Mayor, will soon award contract for waterworks improvements including reservoir, wells, pumps, mains, etc. Devlin Engineering Co., Amarillo, is engineer.

Tex., San Antonio—Baker Hotels Inc., c/o T. B. Baker, Gunter Hotel, plans the construction of a 22 story hotel including steam heating, refrigeration and ventilation systems, boilers, elevators, etc. at St. Marys and Travis Sts. Estimated cost $1,500,000. H. S. Greene, c/o Alamo Bank Bldg., is architect.

Tex., San Antonio—City plans an election soon to vote $50,000 bonds for waterworks improvements including pumping equipment, mains, etc. at Alamo Heights, a suburb of San Antonio. Estimated cost $50,000. P. Villaret, 129 Montclair St., San Antonio, mayor of Alamo Heights.

Tex., San Antonio—Missouri Pacific R.R. Co., Railway Exchange Bldg., St. Louis, Mo., will build a complete system of switching yards, also the reconstruction of refrigeration system at South San Antonio near Camp Normoyle for the International-Great Northern R.R. Co., Union Station, Houston, subsidiary. Estimated cost $250,000. E. A. Hadley, St. Louis, Mo., is chief engineer.

Va., Farmville—City, R. B. Cralle, Mgr., will soon award contract for waterworks improvements including a 750 g.p.m. motor driven centrifugal pump, etc. W. M. Platt, Durham, is engineer.

Ont., Blenheim—Town, P. S. Shillington, Clk., will soon award contract for waterworks improvements including reservoir, pumphouse, pumping equipment, electric centrifugal pumps, etc. Estimated cost $85,000. Wynne-Roberts, Son & McLean, 44 Victoria St., Toronto, are engineers.

Ont., Toronto—Ford Hotel Co., Rochester, N. Y., plans the construction of a 15 story hotel including steam heating system, elevators, etc. at Bay and Dundas Sts., here. Estimated cost $2,000,000.

Que., St. Gabriel de Brandon—City will receive bids until May 13 for the construction of an aqueduct and pumping plant. Estimated cost $50,000. H. Lippe, Joliette, is engineer.

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Equipment Wanted

Boilers, Compressors, Etc.—Mohme Aero Engineering Co., c/o W. E. Arthur, 103 Park Ave., New York, N. Y., Archt. and Engr., is in the market for boilers, compressors, electrical equipment, etc. for proposed factory and boiler house.

Electrical Equipment—Dept. of Public Works, City Hall, Detroit, Mich., will receive bids until May 11 for furnishing and installing electrical equipment including motors, conduits, etc. in intake well at Jefferson and Clairpointe Aves. in connection with pumping unit. Separate contract for pumping equipment.

Engines, Etc.—Pe-Ark Oil & Gas Co., c/o R. G. Bollinger and J. A. Ward, Jr., Adelaide St., Fort Smith, Ark., plans to purchase engines, etc. for proposed land development. Estimated cost $100,000.

Ice Plant Machinery—N. Burnett, Greenville, Tex., is in the market for automatic machinery for proposed 20 ton ice plant. Estimated cost $30,000.

Insulators—State Electricity Commission of Victoria, 32 William St., Melbourne, Australia, will receive bids until July 1 for 300 strings of disc tensioning insulators for use on 66,000 v. circuits, 1250 strings of disc suspension insulators for use on 66,000 v. circuits, 1500 strings of disc suspension insulators complete for use on 22,000 v. circuits, 75 strain clamps complete with ball socket for use with the tensioning strings and 75 strain hooks for use with the tensioning insulator strings.

Motors, Etc. — Barron Oil Burners Co., Collingwood, Ont., prices and catalogs on motors, etc. for oil burners. Estimated cost $50,000.

Power & Light Plant Equipment—Central Power & Light Co., Frost Bldg., San Antonio, Tex., has acquired the Rio Grande City Ice Water & Light Co's plant at Rio Grande, Tex. and plans to expend $25,000 for machinery and equipment.

Pump—City of Carter, Okla., will be in the market for a deep well pump for proposed waterworks system. Estimated cost $31,000.

Pump and Motor—City of Shattuck, Okla., will be in the market for a deep well pump and motor for proposed waterworks improvements. Estimated cost $20,000.

Pumps, Etc.—City of Otis, Kan., will soon receive bids for pumps and equipment for proposed waterworks system. Estimated cost $50,000.

Pumps—City of Locust Grove, Okla., will be in the market for motor driven centrifugal pumps, etc. for proposed waterworks improvements. Estimated cost $125,000.

Pumps—City of Sayre, Okla., will be in the market for two deep well pumps for proposed waterworks improvements. Estimated cost $53,000.

Pumps, Etc.—City of New Madrid, Mo., handed back bids of Apr. 14 for two 150 g.p.m. vertical centrifugal pumps with motors and starters for proposed sewage disposal plant and pumping station owing to the Mississippe flood. New bids will be called later.

Pumping Equipment—City of Butler, Mo., will soon receive bids for pumping equipment, etc. for proposed waterworks improvements.

Pumping Equipment, Etc.—City of Harlingen, Tex., will be in the market for pumping equipment for proposed waterworks improvements, also machinery and equipment for extensions and improvements to electric light plant. Estimated cost $70,000 and $40,000 respectively.

Refrigeration Equipment — Bureau of Yards & Docks, Navy Dept., Washington, D. C., will readvertise for bids for the installation of refrigeration equipment in Naval Operating Base, Hampton Roads, Va. Former bids rejected.

Water Wheels, Mechanical Governor, Etc.—B. R. Power Co., Clifton Station, Va., is in the market for a 250 hp. water wheel, 150 hp. water wheel and alternators for each, with switchboard complete, 3 ph., 60 cycle, 2,300 v., 20 hp. overshot or turbine, d.c. dynamos, 35 ft. head, copper wire, transformer and electrolytic arrester, mechanical governor and oil pressure governor.

PRICES - MATERIALS - SUPPLIES

Electrical prices on following page are prices to the power plant by jobbers in the larger buying centers east of the Mississippi. Elsewhere the prices will be modified by increased freight charges and by local conditions.

SINCE LAST MONTH

DECLINING tendencies in prices of power-plant and electrical supplies were very marked during the last month. Downward revisions from the April levels are shown in the accompanying table on rubber-covered copper wire, flexible cord, armored cable, packing, babbitt metal, and wiping cloths.

POWER-PLANT SUPPLIES

HOSE—Quotations at New York warehouses:

	Fire Protection	50-Ft. Lengths
Underwriters' 2½-in., coupled, sing'le jacket		(net) 68c. per ft.
Common, 2½-in., cotton-rubber lined	.80c. per ft. list less	50%

Air—Best grade

¾-in., per ft.	3-ply	$0.34	4 ply	$0.42

Steam—Discounts from List

First grade	40%	Second grade	40–50%	Third grade	50%

RUBBER BELTING—List price 6-in., 6 ply, $1.83 per lin.ft. The following discounts from list apply to rubber transmission belting:

Best grade	50%	Second grade	50–10%

LEATHER BELTING—List price, 24c. per lin.ft. per inch of width for single ply at New York warehouses.

Grade	Discount from list
Medium	40 5%
Heavy	30 10%

RAWHIDE LACING—For cut, best grade, 50%, 2nd grade, 60%. For laces in sides, best, 41c. per sq.ft.; 2nd, 37c. Semi-tanned: cut, 50%; sides, 41c. per sq.ft.

PACKING—Prices per pound at New York warehouses:

Rubber and duck for low-pressure steam, ⅛ in.	$0.95
Asbestos for high-pressure steam, ⅛ in.	1.75
Duck and rubber for piston packing	.95
Flax, regular	1.15
Flax, waterproofed	1.70
Compressed asbestos sheet	.85
Wire insertion asbestos sheet	1.30
Rubber sheet	.50
Rubber sheet, wire insertion	.80
Rubber sheet, duck insertion	.60
Asbestos packing, twisted or braided and graphited, for valve stems and stuffing boxes	1.40
Asbestos wick, ½- and 1-lb. balls	.50

PIPE AND BOILER COVERING—Discounts, New York warehouses, are as follows:

85% magnesia high pressure		50%
Asbestos, air cell, for low-pressure heating and return lines	4-ply	70%
	3-ply	72%
	2-ply	74%

PORTLAND CEMENT—New York, $2.35@$2.50 per bbl. without bags, in carload lots delivered on job. Bag charge of 40c. per bbl.

STRUCTURAL STEEL—New York delivered price, 3 to 15-in. beams and channels and 3 to 6-in. angles, tees, and plates, all $3.34 per 100 lb.

COTTON WASTE—The following prices are in cents per pound:

	New York	Cleveland	Chicago
White	10.00@13.50	16.00	15.00@20.00
Colored	9.00@13.00	12.00	12.00@17.00

WIPING CLOTHS—Prices per pound in lots of about 600 lb., for washed, white wipers, as follows:

Chicago	$0.15
New York	.15½
Cleveland (*per thousand*)	36.00

LINSEED OIL—These prices are per gallon:

	New York	Cleveland	Chicago
Raw in barrels (5 bbl. lots)	$0.80½	$0.93	$0.87

WHITE AND RED LEAD—Per 100-lb. keg, base price, f.o.b. New York:

	Dry		In Oil	
	Current	1 Yr. Ago	Current	1 Yr. Ago
Red	$15.25	$15.25	$16.75	$16.75
White	15.25	15.25	15.25	15.25

RIVETS—The following quotations are allowed for fair-sized orders from warehouse:

Tank rivets, 7/16-in. dia. and smaller, list (Apr. 1, 1927) less 50-10%, EXTRA per 100 lb. for ½-in. dia., 35c; ⅝-in., 15c; ¾-in., 5c; longer than ¾-in. up to and including 1½-in., 15c; longer than 5-in., 25c; standard countersunk head, 25c.

Structural rivets, per 100 lb.:

New York	$5.00*	Chicago	$3.50	Pittsburgh mill	$2.30@$2.45

Cone-head boiler rivets, per 100 lb.:

New York	$5.00*	Chicago	$3.70	Pittsburgh mill	$3.00

*Full kegs.

REFRACTORIES—Prices in carlots f.o.b. plant:

Chrome brick, eastern shipping points	net ton	$45.00
Chrome cement, 40@50% Cr_2O_3, in bulk	net ton	22@25
Chrome cement, 40@50% Cr_2O_3, in sacks	net ton	26@29
Magnesite brick: 9-in. straights	net ton	65.00
Magnesite brick: 9-in. arches, wedges and keys	net ton	71.50
Magnesite brick: Soaps and spits	per ton	91.00
Silica brick: Mt. Union, Pa.	per M	43.00
Clay brick, 1st quality, 9 in. shapes, Pennsylvania	per M	43@46
Clay brick, 1st quality, 9 in. shapes, Ohio	per M	43@46
Clay brick, 1st quality, 9 in. shapes, Kentucky	per M	43@46
Clay brick, 1st quality, 9 in. shapes, Maryland	per M	43@46
Clay brick, 2nd quality, 9 in. shapes, Pennsylvania	per M	35@38
Clay brick, 2nd quality, 9 in. shapes, Ohio	per M	35@38
Clay brick, 2nd quality, 9 in. shapes, Kentucky	per M	35@38
Clay brick, 2nd quality, 9 in. shapes, Maryland	per M	35@38
Chrome ore crude, 40@50%	net ton	18.00@22.50

BABBITT METAL—Delivered, New York, cents per lb.:

Genuine, highest grade	85.00
Commercial genuine, intermediate grade	61.00
Anti-friction metal, general service	31.50
No. 4 babbitt (f.o.b.)	13.25

COLD DRAWN STEEL—Warehouse prices are as follows:

	New York	Cleveland	Chicago
Round shafting and screw stock, per 100 lb. base	$4.00	$3.90	$3.60
Flats and squares, per 100 lb. base	4.50	4.40	4.10

BOILER FITTINGS—F. o. b. New York or Jersey City, discounts on list:

	Current
Copper ferrules	70%
Boiler flanges	65-5%
Boiler stay bolts	60%
Boiler patch bolts	10%
Boiler fitting-up bolts	45%
Pressed steel boiler lugs	10%

WROUGHT PIPE—The following percentage discounts are to jobbers for carload lots at Pittsburgh mill:

BUTT WELD

Inches	Steel Black	Steel Galv.	Inches	Iron Black	Iron Galv.
1 to 3	62	50½	1 to 1½	30	13

LAP WELD

2	55	43½	2	23	7
2½ to 6	59	47½	2½	26	11
7 and 8	56	43½	3 to 6	28	13
9 and 10	54	41½	7 to 12	26	11
11 and 12	53	40½			

BUTT WELD, EXTRA STRONG, PLAIN ENDS

1 to 1½	60	49½	1 to 1½	30	14
2 and 3	61	50½			

LAP WELD, EXTRA STRONG, PLAIN ENDS

2	53	42½	2	23	9
2½ to 4	57	46½	2½ to 4	29	15
4½ to 6	56	45½	4½ to 6	28	14
7 and 8	52	39½	7 and 8	21	7
9 and 10	45	32½	9 to 12	16	2
11 and 12	44	31½			

BOILER TUBES—Following are net prices per 100 ft. in New York warehouse of tubes manufactured according to specifications of the American Society of Mechanical Engineers.

Size	Lapweld Steel	C. C. Iron	Seamless Steel
1	.....	.....	$17.07
1¼	.....	.....	19.20
1½	.....	$38.00	17.92
1¾	.....	28.50	20.48
2	$17.33	25.00	20.24
2¼	19.84	28.25	23.00
2½	21.60	34.00	26.03
3	25.50	42.50	27.04
3¼	30.25	49.50	30.67
3½	31.50	52.75	33.33
4	38.03	67.00	40.11

Tubes 2½ in. diameter, or smaller, over 18 ft. long, 10 per cent extra.

These prices are net per 100 ft. based on stock lengths. If cut to special ongths, billing will be based on the entire stock lengths.

In addition to the above, standard cutting charges are as follows:

2 in. and smaller, 5c. per cut. 3 in., 9c. per cut
2¼ and 2½ in., 6c. per cut. 3¼ to 4 in., 10c. per cut

ELECTRICAL SUPPLIES

ARMORED CABLE—Price per 1,000 ft.—5 per cent 10 days.

B. & S. Size	Two Cond. M Ft.	Three Cond. M Ft.	Two Cond. Lead M Ft.	Three Cond. Lead M Ft.
No. 14 solid	$30.00 (net)	$50.00 (net)	$180.00	$220.00
No. 12 solid	136.00	180.00	225.00	275.00
No. 10 solid	185.00	235.00	275.00	325.00
No. 8 stranded	305.00	375.00	420.00	500.00
No. 6 stranded	440.00	530.00	615.00	.....

From the above lists discounts are:		Lead Covered
Less than coil lots	50%	20%
Coils to 1,000 ft.	60%	30%
1,000 to 5,000 ft.	62%	35%
5,000 ft. and over	65%	38%

CONDUIT, Price per 1,000 ft.; **ELBOWS AND COUPLINGS**, Per 100 pieces, f.o.b. New York, with 10-day discount of 5 per cent.

Size In.	Conduit Black Per M	Conduit Galvanized Per M	Elbows Black Per C	Elbows Galvanized Per C	Couplings Black Per C	Couplings Galvanized Per C
½	$56.50	$61.34	$7.76	$8.83	$4.52	$4.92
¾	72.07	78.63	10.21	11.63	6.46	7.03
1	103.31	113.00	15.10	17.21	8.39	9.13
1¼	139.77	152.88	20.51	23.07	11.78	12.75
1½	167.12	182.79	27.34	30.76	14.56	15.75
2	224.85	245.94	50.13	56.40	19.41	21.01
2½	355.50	388.85	82.03	92.28	27.73	30.01
3	464.88	508.50	218.74	246.10	41.59	45.01
3½	585.30	637.74	483.04	543.46	55.46	60.02
4	714.17	776.30	558.23	628.06	69.32	75.02

CONDUIT BODIES AND FITTINGS—Black or galvanized.

	Less than $10 list	$10 list to $100	$100 list and over
Standard package	10%	20%	28%
Less than standard package	5%	10%	20%

CUT-OUTS—Following are net prices each in standard-package quantities:

CUT-OUTS, PLUG, SOLID NEUTRAL OR 2 FUSE

S. P. M. L.	$0.12	D. P. D. B.	$0.31
D. P. M. L.	.16	T. P. S. B.	.35
T. P. M. L.	.27	T. P. D. B.	.47
D. P. S. B.	.16		

CUT-OUTS, N. E. C. FUSE, SOLID NEUTRAL OR 2 FUSE

	0-30 Amp.	31-60 Amp.	60-100 Amp.
D. P. M. L.	$0.27	$0.70	$1.75
T. P. M. L.	.40	1.00	2.30
D. P. S. B.	.35	.87	.....
T. P. S. B.	.67	1.50	.....
D. P. D. B.	.65	1.75	.....
T. P. D. B.	1.12	3.00	.....
T. P. to D. P. D. B.	.75	2.10	.....

FLEXIBLE CORD—Price per 1,000 ft. in coils of 250 ft.:

No. 18 cotton reinforced heavy		$17.75
No. 16 cotton reinforced heavy		22.00
No. 18 cotton reinforced light		14.50
No. 16 cotton reinforced light		18.35
No. 18 cotton Canvasite cord		14.75
No. 16 cotton Canvasite cord		17.20
No. 16 super service cord or similar (2 wire) in 1,000 ft.	$82.00	*90.50
No. 14 super service cord or similar (2 wire) in 1,000 ft.	121.00	*133.10

*Less than 1,000 ft.

NATIONAL ELECTRIC CODE FUSES, NON-REFILLABLE—

250-Volt	Std. Pkg.	List	600-Volt	Std. Pkg.	List
3-amp. to 30 amp.	100	$0.15	3-amp. to 30-amp.	100	$0.30
35-amp. to 60-amp.	100	.30	35-amp. to 60-amp.	100	.60
61-amp. to 100 amp.	50	.90	65-amp. to 100-amp.	50	1.50
101-amp. to 200-amp.	25	2.00	110-amp. to 200-amp.	25	2.50
201-amp. to 400-amp.	25	3.60	225-amp. to 400-amp.	25	5.50
401-amp. to 600-amp.	10	5.50	450-amp. to 600-amp.	10	8.00

Discount: Less 1-5th standard package, 60%; 1-5th to standard package, 64%; standard package, 68%.

RENEWABLE FUSES—List price each:

Sizes	250-Volt List-Price	600-Volt List-Price	Std. Pkg. Quantity	Carton Quantity
1 to 30-amp.	$0.50	$1.10	100	10
35 to 60-amp.	1.00	1.25	100	10
65 to 100-amp.	2.00	3.00	50	5
110 to 200-amp.	4.00	5.00	25	5
225 to 400-amp.	7.50	11.00	25	1
450 to 600-amp.	11.00	16.00	10	1

REFILLS—

1 to 30-amp.	$0.03 ea.	$0.05	100	100
35 to 60-amp.	.05 ea.	.06	100	100
65 to 100-amp.	.10 ea.	.10	50	50
110 to 200-amp.	.15 ea.	.15	25	50
225 to 400-amp.	.30 ea.	.30	25	25
450 to 600-amp.	.60 ea.	.60	10	10

Discount Without Contract—Fuses:	
Broken carton	5%
Unbroken carton but less than std. pkg.	22%
Std. pkg.	40%
Discount Without Contract—Renewals:	
Less than std. pkg.	Net list
Standard package	40%
Discount With Contract—Fuses:	
Broken cartons	10%
Unbroken cartons but less than standard package	26%
Standard package	42%
Discount With Contract—Renewals:	
Less standard package	Net list
Standard package	42%

FUSE PLUGS, MICA CAP—

0-30 ampere, standard package (500)	$2.75
0-30 ampere, less than standard package	3.00

LAMPS—Below are present quotations in less than standard package quantities on Mazda standard A type bulbs:

100—130 Volt Watts	Type	Price Each	200—260 Volt Watts	Type	Price Each
15	A 17	$0.23		Special	
	General		25	A 19	$0.28
25	A 19	.23	50	A 21	.28
40	A 21	.23	100	A 23	.50
50	A 21	.25			
60	A 21	.25			
100	A 23	.40			

Standard pkg. quantities are subject to discount of 10% from list. Annual contracts ranging from $75 to $300,000 net allow a discount of 15 to 40% from list.

PLUGS, ATTACHMENT—

	Each
Porcelain separable attachment plug	$0.18
Composition 2-piece attachment plug	.27
Swivel attachment plug	.12
Small size—2 Pc. Plug—Composition	.07

RUBBER-COVERED COPPER WIRE—Per 1000 ft. f. o. b. New York:

No.	Solid Single Braid	Solid Double Braid	Stranded, Double Braid	Solid Duplex
14	$6.00	$9.00	$10.80	$17.05
12	9.70	12.20	14.20	23.20
10	12.80	15.70	18.10	30.15
8	18.70	21.40	23.70	41.75
6	.....	.....	33.75	.....
4	.....	.....	47.00	.....
2	.....	.....	66.25	.....
1	.....	.....	91.00	.....
0	.....	.....	112.50	.....
00	.....	.....	133.00	.....
000	.....	.....	159.40	.....
0000	.....	.....	190.24	.....

SOCKETS, BRASS SHELL—Price each, net:

	½ In. or Pendant Cap Key	½ In. or Pendant Cap Keyless	½ In. or Pendant Cap Pull	¾ In. Cap Key	¾ In. Cap Keyless	¾ In. Cap Pull
Standard package	$0.17	$0.15	$0.22	$0.20	$0.18	$0.25
Unbroken carton	.18	.16	.23	.22	.19	.26
Broken carton	.20	.18	.25	.24	.21	.28

WIRING SUPPLIES—

Friction tape, ¾ in., less 100 lb. 33c. lb.; 100 lb. lots	31c. lb.
Rubber tape, ¾ in., less 100 lb. 35c. lb.; 100 lb. lots	33c. lb.
Wire solder, less 100 lb. 33c. lb., 100 lb. lots	31c. lb.
Soldering paste, 2 oz. cans	$1.00 doz.

ENCLOSED SWITCHES, KNIFE—Safety type, externally operated, 250 d.c. or a.c., N.E.C.

TYPE "C" FUSED BOTTOM

Size, Amp.	Double Pole, Each	Three Pole, Each	Four Pole Each
30	$4.50	$6.00	$7.25
60	7.50	8.25	10.50
100	10.50	13.00	22.50
200	16.00	20.00	36.00

Discounts:	
Less than $25.00 list value	30%
$25.00 to $50.00 list value	30-5%
$50.00 list value or over	35%